PALÆONTOGRAPHICAL SOCIETY.

VOL. XXXII.

CRETACEOUS ECHINODERMATA.

VOL. I; PART VIII.

(EPIASTER, MICRASTER, ECHINOSPATAGUS, ENALLASTER, AND CARDIASTER.)

PAGES 265—300; PLATES LXIIA, LXIII—LXIX.

OOLITIC ECHINODERMATA.

VOL. I; PART V.

(INDEX AND TITLE-PAGE.)

PAGES i—iv; 469—481.

FOSSIL MEROSTOMATA.

PART V.

(NEOLIMULUS, BELLINURUS, PRESTWICHIA, AND CYCLUS.)

PAGES i—ii, 181—263; PLATES XXXI—XXXVI.

FOSSIL BRACHIOPODA SUPPLEMENT.

PART II; No. I.

(JURASSIC AND TRIASSIC.)

PAGES 145—241; PLATES XVII—XXIX.

LIAS AMMONITES.

PART I.

(ZONES OF THE LIAS.)

PAGES 1—48; PLATES I—VIII.

SIRENOID GANOIDS.

PART I.

(CERATODUS.)

PAGES 1—32; PLATES I, IA, II—V.

WEALDEN REPTILIA SUPPLEMENT.

No. VIII.

(GONIOPHOLIS, PETROSUCHUS, AND SUCHOSAURUS.)

PAGES 1—15; PLATES I—VI.

PLEISTOCENE MAMMALIA.

PART A.

(PRELIMINARY TREATISE.)

PAGES *i—xxviii.*

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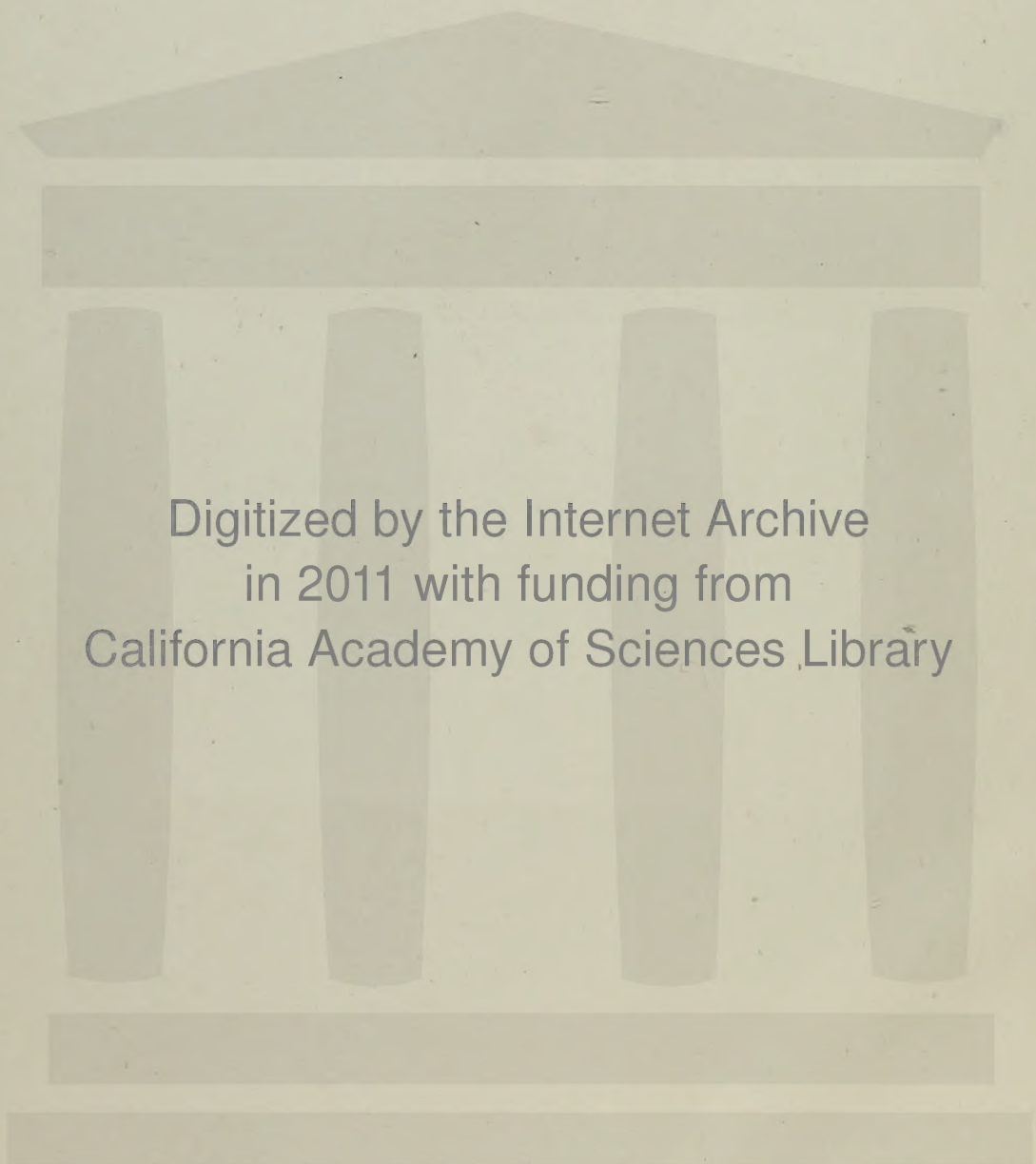
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II. A CLASSIFIED LIST OF THE MONOGRAPHS COMPLETED, IN COURSE OF PUBLICATION, AND IN PREPARATION, WITH THE NAMES OF THEIR RESPECTIVE AUTHORS;

III. THE DATES OF ISSUE OF THE ANNUAL VOLUMES;

IV. A GENERAL SUMMARY, SHOWING THE NUMBER OF THE PAGES, PLATES, FIGURES, AND SPECIES IN EACH MONOGRAPH;

V. A STRATIGRAPHICAL LIST OF THE BRITISH FOSSILS FIGURED AND DESCRIBED IN THE YEARLY VOLUMES.

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„ XII.	„	1858	The Fossil Echinodermata, Part IV, Oolitic, by Dr. Wright, 7 plates. The Eocene Mollusca, Part III, No. 3, Prosobranchiata continued, by Mr. F. E. Edwards, 6 plates. The Reptilia of the Cretaceous Formations (Supplements No. 2, No. 3), by Prof. Owen, 7 plates. The Reptilia of the Purbeck Limestones, by Prof. Owen, 1 plate. The Fossil Brachiopoda, Part V, No. 3, Carboniferous, by Mr. Davidson, 10 plates.
„ XIII.	„	1859	The Fossil Brachiopoda, Part V, No. 4, Carboniferous, by Mr. Davidson, 20 plates. The Reptilia of the Oolitic Formations, No. 1, Lower Lias, by Prof. Owen, 6 plates. The Reptilia of the Kimmeridge Clay, No. 1, by Prof. Owen, 1 plate. The Eocene Mollusca, Part IV, No. 1, Bivalves, by Mr. S. V. Wood, 13 plates.
„ XIV.	„	1860	The Fossil Brachiopoda, Part V, No. 5, Carboniferous, by Mr. Davidson, 8 plates. The Reptilia of the Oolitic Formation, No. 2, Lower Lias, by Prof. Owen, 11 plates. The Reptilia of the Kimmeridge Clay, No. 2, by Prof. Owen, 1 plate. The Fossil Estheriæ, by Prof. Rupert Jones, 5 plates. The Fossil Crustacea, Part II, Gault and Greensand, by Prof. Bell, 11 plates.
„ XV.	„	1861	The Fossil Echinodermata, Vol. II, Part I (Oolitic Asteroidea), by Dr. Wright, 13 plates. Supplement to the Great Oolite Mollusca, by Dr. Lycett, 15 plates.

* This Vol. is marked on the outside 1855.

† This Vol. is marked on the outside 1856.

CATALOGUE OF WORKS—Continued.

Vol. XVI.	Issued for the Year 1862		The Fossil Echinodermata, Cretaceous, Vol. I, Part I, by Dr. Wright, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part I, by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VI, No. 1, Devonian, by Mr. Davidson, 9 plates. The Eocene Mollusca, Part IV, No. 2, Bivalves, by Mr. S. V. Wood, 7 plates. The Reptilia of the Cretaceous and Wealden Formations (Supplements), by Prof. Owen, 10 plates.
„ XVII.	„	1863	The Trilobites of the Silurian, Devonian, &c., Formations, Part II, by Mr. J. W. Salter, 8 plates. The Fossil Brachiopoda, Part VI, No. 2, Devonian, by Mr. Davidson, 11 plates. The Belemnitidæ, Part I, Introduction, by Prof. Phillips. The Reptilia of the Liassic Formations, Part I, by Prof. Owen, 16 plates.
„ XVIII.	„	1864	The Fossil Echinodermata, Vol. II, Part II (Liassic Ophiuroidea), by Dr. Wright, 6 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part III, by Mr. J. W. Salter, 11 plates. The Belemnitidæ, Part II, Liassic Belemnites, by Prof. Phillips, 7 plates. The Pleistocene Mammalia, Part I, Introduction, Felis spelæa, by Messrs. W. Boyd Dawkins and W. A. Sanford, 5 plates. Title-pages, &c., to the Monographs on the Reptilia of the London Clay, Cretaceous, and Wealden Formations.
„ XIX.*	„	1865	The Crag Foraminifera, Part I, No. 1, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady, 4 plates. Supplement to the Fossil Corals, Part I, Tertiary, by Dr. Duncan, 10 plates. The Fossil Merostomata, Part I, Pterygotus, by Mr. H. Woodward, 9 plates. The Fossil Brachiopoda, Part VII, No. 1, Silurian, by Mr. Davidson, 12 plates.
„ XX.*	„	1866	Supplement to the Fossil Corals, Part IV, No. 1, Liassic, by Dr. Duncan, 11 plates. The Trilobites of the Silurian, Devonian, &c., Formations, Part IV (Silurian), by Mr. J. W. Salter, 6 plates. The Fossil Brachiopoda, Part VII, No. 2, Silurian, by Mr. Davidson, 10 plates. The Belemnitidæ, Part III, Liassic Belemnites, by Prof. Phillips, 13 plates.
„ XXI.*	„	1867	Flora of Carboniferous Strata, Part I, by Mr. E. W. Binney, 6 plates. Supplement to the Fossil Corals, Part IV, No. 2, Liassic, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part II, by Dr. Wright, 14 plates. The Fishes of the Old Red Sandstone, Part I, by Messrs. J. Powrie and E. Ray Lankester, 5 plates. The Pleistocene Mammalia, Part II, Felis spelæa, continued, by Messrs. W. Boyd Dawkins and W. A. Sanford, 14 plates.
„ XXII.*	„	1868	Supplement to the Fossil Corals, Part II, No. 1, Cretaceous, by Dr. Duncan, 9 plates. The Fossil Merostomata, Part II, Pterygotus, by Mr. H. Woodward, 6 plates. The Fossil Brachiopoda, Part VII, No. 3, Silurian, by Mr. Davidson, 15 plates. The Belemnitidæ, Part IV, Liassic and Oolitic Belemnites, by Prof. Phillips, 7 plates. The Reptilia of the Kimmeridge Clay, No. 3, by Prof. Owen, 4 plates. The Pleistocene Mammalia, Part III, Felis spelæa, concluded, with F. lynx, by Messrs. W. Boyd Dawkins and W. A. Sanford, 6 plates.
„ XXIII.*	„	1869	Supplement to the Fossil Corals, Part II, No. 2, Cretaceous, by Dr. Duncan, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part III, by Dr. Wright, 10 plates. The Belemnitidæ, Part V, Oxford Clay, &c., Belemnites, by Prof. Phillips, 9 plates. The Fishes of the Old Red Sandstone, Part I (concluded), by Messrs. J. Powrie and E. Ray Lankester, 9 plates. The Reptilia of the Liassic Formations, Part II, by Prof. Owen, 4 plates. The Crag Cetacea, No. 1, by Prof. Owen, 5 plates.
„ XXIV.*	„	1870	The Flora of the Carboniferous Strata, Part II, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part IV, by Dr. Wright, 10 plates. The Fossil Brachiopoda, Part VII, No. 4, Silurian, by Mr. Davidson, 13 plates. The Eocene Mollusca, Part IV, No. 3, Bivalves, by Mr. S. V. Wood, 5 plates. The Fossil Mammalia of the Mesozoic Formations, by Prof. Owen, 4 plates.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in one cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope. The previous volumes are not in separate parts.

CATALOGUE OF WORKS—Continued.

Vol. XXV.*	Issued for the Year 1871	The Flora of the Carboniferous Strata, Part III, by Mr. E. W. Binney, 6 plates. The Fossil Merostomata, Part III, Pterygotus and Slimonia, by Mr. H. Woodward, 5 plates. Supplement to the Crag Mollusca, Part I (Univalves), by Mr. S. V. Wood, with an Introduction on the Crag District, by Messrs. S. V. Wood, jun., and F. W. Harmer, 7 plates and map. Supplement to the Reptilia of the Wealden (Iguanodon), No. IV, by Prof. Owen, 3 plates The Pleistocene Mammalia, Part IV, Felis pardus, &c., by Messrs W. Boyd Dawkins and W. A. Sanford, 2 plates. The Pleistocene Mammalia, Part V, Ovibos moschatus, by Mr. W. Boyd Dawkins, 5 plates.
„ XXVI*	„ 1872	Supplement to the Fossil Corals, Part III (Oolitic), by Prof. Duncan, with an Index to the Tertiary and Secondary Species, 7 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part V, by Dr. Wright, 5 plates. The Fossil Merostomata, Part IV (Stylonurus, Eurypterus, Hemiaspis), by Mr. H. Woodward, 10 plates. The Fossil Trigoniæ, No. I, by Dr. Lycett, 9 plates.
„ XXVII*	„ 1873	The Fossil Echinodermata, Cretaceous, Vol I, Part VI, by Dr. Wright, 8 plates. Supplement to the Fossil Brachiopoda, Part I (Tertiary and Cretaceous), by Mr. Davidson, 8 plates. Supplement to the Crag Mollusca, Part II (Bivalves), by Mr. S. V. Wood, 5 plates. Supplement to the Reptilia of the Wealden (Iguanodon), No. V, by Prof. Owen, 2 plates. Supplement to the Reptilia of the Wealden (Hylæochampsa) No. VI, by Prof. Owen. The Fossil Reptilia of the Mesozoic Formations, Part I, by Prof. Owen, 2 plates.
„ XXVIII*	„ 1874	The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, 16 plates. The Carboniferous Entomostraca, Part I (Cypridinadæ), by Prof. T. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, 5 plates. The Fossil Trigoniæ No. II, by Dr. Lycett, 10 plates.
„ XXIX*	„ 1875	The Flora of the Carboniferous Strata, Part IV, by Mr. E. W. Binney, 6 plates. The Fossil Echinodermata, Cretaceous, Vol. I, Part VII, by Dr. Wright, 10 plates. The Fossil Trigoniæ, No. III, by Dr. Lycett, 8 plates. The Fossil Reptilia of the Mesozoic Formations, Part II, by Prof. Owen, 20 plates.
„ XXX.*	„ 1876	The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady, 12 plates. Supplement to the Fossil Brachiopoda, Part II, No. 1 (Jurassic and Triassic), by Mr. Davidson, 8 plates. Supplement to the Reptilia of the Wealden (Poikilopleuron and Chondrosteosaurus), No. VII, by Prof. Owen, 6 plates.
„ XXXI.*	„ 1877	Supplement to the Eocene Mollusca (Bivalves), by Mr. S. V. Wood, 2 plates. The Fossil Trigoniæ, No. IV, by Dr. Lycett, 13 plates. The Eocene Mollusca (Univalves), Part IV, by Mr. S. V. Wood, 1 plate. The Carboniferous Ganoid Fishes, Part I (Palæoniscidæ), by Dr. Traquair, 7 plates. The Fossil Reptilia of the Mesozoic Formations, Part III, by Prof. Owen, 2 plates. The Fossil Elephants (E. antiquus), Part I, by Prof. Leith Adams, 5 plates.
„ XXXII.	„ 1878	The Fossil Echinodermata, Cretaceous, Vol. I, Part VIII, by Dr. Wright, 8 plates. Index and Title Page to the Fossil Echinodermata, Oolitic, Vol. I (Echinoidea), by Dr. Wright. The Fossil Merostomata, Part V (Neolimulus, &c.), by Dr. H. Woodward, 6 plates. Supplement to the Fossil Brachiopoda, Part II, No. 2 (Jurassic and Triassic), by Mr. Davidson, 13 plates. The Lias Ammonites, Part I, by Dr. Wright, 8 plates. The Sirenoid and Crossopterygian Ganoids, Part I, by Prof. Miall, 6 plates. Supplement to the Reptilia of the Wealden (Goniopholis, Petrosuchus, and Suchosaurus), No. VIII, by Prof. Owen, 6 plates. The Pleistocene Mammalia, Part A (Preliminary Treatise), by Prof. Boyd Dawkins.

* These Volumes are issued in two forms of binding; first, with all the Monographs stitched together and enclosed in cover; secondly, with each of the Monographs separate, and the whole of the separate parts placed in an envelope.

§ II. LIST OF MONOGRAPHS

Completed, in course of Publication, and in Preparation.

1. MONOGRAPHS which have been COMPLETED, and which may be bound as separate Volumes:—

The Carboniferous and Permian Foraminifera (the genus Fusulina excepted), by Mr. H. B. Brady.
The Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne Edwards and J. Haime.
The Polyzoa of the Crag, by Mr. G. Busk.
The Tertiary Echinodermata, by Professor Forbes.
The Fossil Cirripedes, by Mr. C. Darwin.
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, the Rev. H. W. Crosskey, and Mr. D. Robertson.
The Tertiary Entomostraca, by Prof. T. Rupert Jones.
The Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Fossil Estheriæ, by Prof. T. Rupert Jones.
The Fossil Merostomata, by Mr. H. Woodward.
The Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, Devonian, and Silurian Brachiopoda, by Mr. T. Davidson.
The Eocene Bivalves, Vol. I and Supplement, by Mr. S. V. Wood.
The Eocene Cephalopoda and Univalves, Vol. I, by Mr. F. E. Edwards and Mr. S. V. Wood.
The Mollusca of the Crag, by Mr. S. V. Wood.
Supplement to the Crag Mollusca, by Mr. S. V. Wood.
The Great Oolite Mollusca, by Professor Morris and Mr. J. Lycett.
The Oolitic Echinoidea, by Dr. Wright.
The Cretaceous (Upper) Cephalopoda, by Mr. D. Sharpe.
The Fossils of the Permian Formation, by Professor King.
The Reptilia of the London Clay (and of the Bracklesham and other Tertiary Beds), by Professors Owen and Bell.
The Reptilia of the Cretaceous, Wealden, and Purbeck Formations, by Professor Owen.
The Fossil Mammalia of the Mesozoic Formations, by Professor Owen.

2. MONOGRAPHS in course of PUBLICATION:*—

The Flora of the Carboniferous Formation, by Mr. E. W. Binney.
The Crag Foraminifera, by Messrs. T. Rupert Jones, W. K. Parker, and H. B. Brady.
Supplement to the Fossil Corals, by Dr. Duncan.
The Echinodermata of the Oolitic and Cretaceous Formations, by Dr. Wright.

* Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

MONOGRAPHS in course of PUBLICATION—*Continued.*

The Carboniferous Entomostraca, by Messrs. T. Rupert Jones, J. W. Kirkby, and G. S. Brady.
The Trilobites of the Mountain-Limestone, Devonian, and Silurian Formations, by Mr. J. W. Salter.*
The Malacostracous Crustacea, by Professor Bell.
Supplement to the Fossil Brachiopoda, by Mr. T. Davidson.
The Trigoniæ, by Dr. Lycett.
The Ammonites of the Lias, by Dr. Wright.
The Belemnites, by Professor Phillips.†
The Sirenoid and Crossopterygian Ganoids, by Professor Miall.
The Fishes of the Carboniferous Formation, by Prof. Traquair.
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, and Professor Traquair.
The Reptilia of the Wealden Formation (Supplements), by Professor Owen.
The Reptilia of the Kimmeridge Clay, by Professor Owen.
The Reptilia of the Liassic Formations, by Professor Owen.
The Reptilia of the Mesozoic Formations, by Professor Owen.
The Fossil Elephants, by Prof. Leith Adams.
The Pleistocene Mammalia, by Messrs. Boyd Dawkins and W. A. Sanford.
The Cetacea of the Crag, by Professor Owen.

* Unfinished through the death of the Author, but will be continued by Dr. H. Woodward.
† Unfinished through the death of the Author, but will be continued by Mr. R. Etheridge.

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3. MONOGRAPHS which are in course of PREPARATION :‡—

The Eocene Flora, by Mr. J. S. Gardner and Baron Ettinghausen.
The Fossil Cycadeæ, by Mr. W. Carruthers.
The Rhizopoda of the Chalk, Chalk Marl, Gault, and Upper Greensand, by Mr. H. B. Brady.
The Foraminifera of the Lias, by Mr. H. B. Brady.
The Graptolites, by Professor Sir Wyville Thomson.
The Polyzoa of the Chalk Formation, by Mr. G. Busk.
The Palæozoic Polyzoa, by Dr. Duncan.
The Crinoidea, by Professor Sir Wyville Thomson.
Supplement to the Tertiary and Cretaceous Entomostraca, by Prof. T. Rupert Jones.
The Wealden, Purbeck, and Jurassic Entomostraca, by Messrs. T. R. Jones and G. S. Brady.
The Post-Tertiary Mollusca, by Dr. J. Gwyn Jeffreys.
The Cretaceous Mollusca (exclusive of the Brachiopoda), by the Rev. T. Wiltshire.
The Purbeck Mollusca, by Mr. R. Etheridge.
The Inferior Oolite Mollusca, by Mr. R. Etheridge.
The Rhætic Mollusca, by Mr. R. Etheridge.
The Liassic Gasteropoda, by Mr. Ralph Tate.
The Carboniferous Bivalve Mollusca, by Mr. R. Etheridge, junr.

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‡ Members having specimens which might assist the authors in preparing their respective Monographs are requested to communicate in the first instance with the Honorary Secretary.

§ III. Dates of the Issue of the Yearly Volumes of the Palæontographical Society.

The Volume for	1847	was issued	to	the Members,	March, 1848.
,,	1848	,,	,,	,,	July, 1849.
,,	1849	,,	,,	,,	August, 1850.
,,	1850	,,	,,	,,	June, 1851.
,,	1851	,,	,,	,,	June, 1851.
,,	1852	,,	,,	,,	August, 1852.
,,	1853	,,	,,	,,	December, 1853.
,,	1854	,,	,,	,,	May, 1855.
,,	1855	,,	,,	,,	February, 1857.
,,	1856	,,	,,	,,	April, 1858.
,,	1857	,,	,,	,,	November, 1859.
,,	1858	,,	,,	,,	March, 1861.
,,	1859	,,	,,	,,	December, 1861.
,,	1860	,,	,,	,,	May, 1863.
,,	1861	,,	,,	,,	May, 1863.
,,	1862	,,	,,	,,	August, 1864.
,,	1863	,,	,,	,,	June, 1865.
,,	1864	,,	,,	,,	April, 1866.
,,	1865	,,	,,	,,	December, 1866.
,,	1866	,,	,,	,,	June, 1867.
,,	1867	,,	,,	,,	June, 1868.
,,	1868	,,	,,	,,	February, 1869.
,,	1869	,,	,,	,,	January, 1870.
,,	1870	,,	,,	,,	January, 1871.
,,	1871	,,	,,	,,	June, 1872.
,,	1872	,,	,,	,,	October, 1872.
,,	1873	,,	,,	,,	February, 1874.
,,	1874	,,	,,	,,	July, 1874.
,,	1875	,,	,,	,,	December, 1875.
,,	1876	,,	,,	,,	December, 1876.
,,	1877	,,	,,	,,	February, 1877.
,,	1878	,,	,,	,,	March, 1878.

§ IV. SUMMARY OF THE MONOGRAPHS ISSUED TO THE MEMBERS (*up to* MARCH, 1878): *showing in the* FIRST *column whether each Monograph hitherto published be* complete, *or in the* course of completion; *in the* SECOND *column, the yearly volumes which contain each particular Monograph (as a guide to binding the same); and in the* FOURTH *and following columns, the number of pages, plates, figures, and species described in the different Monographs.*

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
The Flora of the Carboniferous Strata, by Mr. E. W. Binney, *in course of completion*	1867, 1870, 1871, 1875	1868, 1871, 1872, 1875	147	24	141	16
The Crag Foraminifera, by Messrs. T Rupert Jones, W, K. Parker, and H. B. Brady, *in course of completion*	1865	1866	78	4	211	43
The Carboniferous and Permian Foraminifera (genus Fusilina excepted), by Mr. H. B. Brady, COMPLETE	1876	1876	166	12	266	62
Tertiary, Cretaceous, Oolitic, Devonian, and Silurian Corals, by MM. Milne-Edwards and J. Haime, COMPLETE (*k*)	1849, 1851, 1852, 1853, 1854	1850, 1851, 1852, 1853, 1855	406	72	800	319*g*
Supplement to the Fossil Corals, by Prof. Duncan, *in course of completion*	1865, 1866, 1867, 1868, 1869, 1872	1866, 1867, 1868, 1869, 1870, 1872	232	49	797	149
The Polyzoa of the Crag, by Mr. G. Busk, COMPLETE	1857	1859	145	22	641	122
The Tertiary Echinodermata, by Prof. Forbes, COMPLETE	1852	1852	39	4	144	44
The Oolitic Echinodermata, by Dr. Wright. Vol. I, COMPLETE (*l*)	1855, 1856, 1857, 1858, 1878	1857, 1858, 1859, 1861, 1878	491	43	724	109*h*
„ „ Vol. II, *in course of completion*	1861, 1864	1863, 1866	154	19	218	29
The Cretaceous Echinodermata, by Dr. Wright. Vol. I, *in course of completion*	1862, 1867, 1869, 1870, 1872, 1873, 1875, 1878	1864, 1868, 1870, 1871, 1872, 1874, 1875, 1878	300	76	977	97
The Fossil Cirripedes, by Mr. C. Darwin, COMPLETE	1851, 1854, 1858*a*	1851, 1855, 1861	137	7	320	54
The Fossil Merostomata, by Dr. H. Woodward, COMPLETE	1865, 1868, 1871, 1872, 1878	1866, 1869, 1872, 1872, 1878	265	36	365	51
The Post-Tertiary Entomostraca, by Mr. G. S. Brady, Rev. H. W. Crosskey, and Mr. D. Robertson, COMPLETE	1874	1874	237	16	515	134
The Tertiary Entomostraca, by Prof. Rupert Jones, COMPLETE	1855	1857	74	6	233	56
The Cretaceous Entomostraca, by Prof. Rupert Jones, COMPLETE	1849	1850	41	7	176	27
The Carboniferous Entomostraca, by Prof. Rupert Jones and Messrs. J. W. Kirkby and G. S. Brady, *in course of completion*	1874	1874	56	5	285	50
The Fossil Estheriæ, by Prof. Rupert Jones, COMPLETE	1860	1863	139	5	158	19*i*
The Trilobites of the Mountain-limestone, Devonian, Silurian, and other Formations, by Mr. J. W. Salter (incomplete through the Author's death)	1862, 1863, 1864, 1866	1864, 1865, 1866, 1867	216	31	703	114
The Malacostracous Crustacea (comprising those of the London Clay, Gault, and Greensands), by Prof. T. Bell, *in course of completion*	1856, 1860	1858, 1863	88	22	215	50
Fossil Brachiopoda, Vol. I. The Tertiary, Cretaceous Oolitic, and Liassic Brachiopoda, by Mr. T. Davidson, COMPLETE	1850, 1852, 1853, 1854	1851, 1852, 1853, 1855	409	42	1855	160
„ „ Vol. II. The Permian and Carboniferous Brachiopoda, COMPLETE	1856*d*, 1857, 1858, 1859, 1860	1858, 1859, 1861, 1861, 1863	331	59	1909	157
„ „ Vol. III. The Devonian and Silurian Brachiopoda, COMPLETE	1862, 1863, 1865, 1866, 1868, 1870	1864, 1865, 1866, 1867, 1869, 1871	528	70	2766	321
		CARRIED FORWARD...	4679	631	14,419	2183

I. SUBJECT OF MONOGRAPH.	II. Dates of the Years *for which* the volume containing the Monograph was issued.	III *m*. Dates of the Years *in which* the Monograph was published.	IV. No. of Pages of Letterpress in each Monograph.	V. No. of Plates in each Monograph.	VI. No. of Lithographed Figures and of Woodcuts.	VII. No. of Species described in the Text.
		BROUGHT FORWARD...	4679	631	14,419	2183
Supplement to the Fossil Brachiopoda, by Mr. Davidson, *in course of completion*	1873, 1876, 1878	1874, 1876, 1878	241	29	1,258	170
The Trigoniæ, by Dr. Lycett, *in course of completion*	1872, 1874, 1875, 1877	1872, 1874, 1875, 1877	204	40	417	111
The Mollusca of the Crag, by Mr. S. V. Wood:—						
Vol. I. (Univalves), COMPLETE.....	1847, 1855*b*	1848, 1857	216	21	581	244
Vol. II. (Bivalves), COMPLETE	1850, 1853, 1855, 1858*c*	1851, 1853, 1857, 1861	344	31	691	253
Supplement to the Crag Mollusca, by Mr. S. V. Wood, COMPLETE.....	1871, 1873	1872, 1874	262	12	360	172
The Eocene Mollusca, Cephalopoda and Univalves, by Mr. F. E. Edwards, continued by Mr. S. V. Wood. Vol. I, COMPLETE	1848, 1852, 1854, 1855, 1858, 1877	1849, 1852, 1855, 1857, 1861, 1877	361	34	625	275
The Eocene Mollusca, Bivalves, by Mr. S. V. Wood. Vol. I, COMPLETE.....	1859, 1862, 1870	1861, 1864, 1871	182	25	531	194
Supplement to the Eocene Mollusca, by Mr. S. V. Wood (Bivalves). Vol. I, COMPLETE..... ...	1877	1877	24	2	66	30
The Great Oolite Mollusca, by Prof. Morris and Dr. Lycett, COMPLETE.....	1850, 1853, 1854	1850, 1853, 1855	282	30	846	419
„ „ „ Supplement by Dr. Lycett, COMPLETE	1861	1863	129	15	337	194
The Liassic Ammonites, by Dr. Wright, *in course of completion*	1878	1878	48	8	41	0
The Belemnites, by Prof. Phillips, *in course of completion*	1863, 1864, 1866, 1868, 1869	1865, 1866, 1867, 1869, 1870	128	36	622	69
The Upper Cretaceous Cephalopoda, by Mr. D. Sharpe, COMPLETE.....	1853, 1854, 1855	1853, 1855, 1857	67	27	319	79
The Fossils of the Permian Formation, by Prof. King, COMPLETE	1849, 1854*e*	1850, 1855	287	29	511	138
The Sirenoid Ganoids, by Prof. Miall, *in course of completion*	1878	1878	32	6	61	6
The Fishes of the Carboniferous Formation, by Dr. Traquair, *in course of completion*	1877	1877	60	7	58	5
The Fishes of the Old Red Sandstone, by Messrs. J. Powrie and E. Ray Lankester, *in course of completion*	1867, 1869	1868, 1870	62	14	195	21
The Reptilia of the London Clay [and of the Bracklesham and other Tertiary Beds], by Profs. Owen and Bell, COMPLETE ‡.....	1848, 1849, 1856*f*	1849, 1850, 1859	150	58	304	39
The Reptilia of the Cretaceous Formations, by Prof. Owen, COMPLETE‡.....	1851, 1857, 1858, 1862	1851, 1859, 1861, 1864	184	59	519	26
The Reptilia of the Wealden and Purbeck Formations, by Prof. Owen, COMPLETE ‡	1853, 1854, 1855, 1856, 1857, 1858, 1862	1853, 1855, 1857, 1858, 1859, 1861, 1864	155	62	251	17
The Reptilia of the Wealden Formations (Supplements) *in course of completion*.....	1871, 1873, 1876, 1878	1872, 1874, 1876, 1878	62	17	105	9
The Reptilia of the Kimmeridge Clay Formation, by Prof. Owen, *in course of completion*	1859, 1860, 1868	1861, 1863, 1869	16	6	23	3
The Reptilia of the Liassic Formations, by Prof. Owen, *in course of completion*	1859,‖ 1860,‖ 1863, 1869	1861, 1863, 1865, 1870	121	37	177	8
The Reptilia of the Mesozoic Formations, by Prof. Owen, *in course of completion*	1873, 1875, 1877	1874, 1875, 1877	97	24	165	17
The Crag Cetacea, by Prof. Owen, *in course of completion*	1869	1870	40	5	43	7
The Fossil Elephants, by Prof. Leith Adams, *in course of completion*	1877	1877	68	5	18	1
The Pleistocene Mammalia, by Messrs. W. Boyd Dawkins and Mr. W. A. Sanford, *in course of completion*	1864, 1867, 1868, 1871, 1878	1866, 1868, 1869, 1872, 1878	304	32	253	7
The Mammalia of the Mesozoic Formations, by Prof. Owen, COMPLETE	1870	1871	115	4	247	30
		TOTAL.....	8920	1306	24,043	4727

a Index. *b* Title-page to Univalves. *c* Note to Crag Mollusca. *d* Contains the Permian. *e* Two corrections of Plates. *f* Supplement.
g Many of the species are described, but not figured. *h* British species only reckoned. *i* British species only reckoned. *k* A Supplement is now in course of publication.
l Index will be found in 1878 vol. *m* Useful for establishing the dates of new species.
‡ Title-pages and Index will be found in the 1864 Volume, or may be had separately. ‖ Marked on outside label 'Reptilia of Oolitic Formations.'

§ V. Stratigraphical Table *exhibiting the* British Fossils *already figured and described in the* Annual Volumes (1847—1878) *of the* Palæontographical Society.

	PLANTS.	PROTOZOA.		RADIATA.		ARTICULATA.					
		Sponges.	Foraminifera.	Corals.	Echinodermata.	Cirripedes.	Cypridæ, Cytherinæ, &c.	Estheriæ.	Merostomata.	Trilobites.	Malacostracous Crustacea.
Pleistocene	...	...	...	...	.....	.....	1874				
Crag	...	...	1865	1849	1852	1851 1854					
Eocene	...	...	...	1849 1865	1852	1851 1854	1855	...	.....	.....	1856
Cretaceous.....	...	...	...	1849 1868 1869	1862 1867 1869 1870 1872 1873 1875 1878	1851 1854	1849	...	.....	.....	1860
Wealden	...	...	...	...	.....	.....	...	1860			
Oolitic	...	...	...	1851 1872	1855, 1856, 1857, 1858, 1861, 1878,	1851	...	1860			
Liassic	...	...	...	1851 1866 1867	1855, 1856, 1858, 1861, 1864						
Triassic	...	...	...	...	.....	.....	...	1860			
Permian	1849	1849	1849 1876	1849 1852	1849	.....	1849	1860			
Carboniferous...	1867 1870 1871 1875	...	1876	1852	.....	.....	1874	1860	1872 1878		
Devonian	...	...	...	1853	.....	.....	...	1860	1865 1868 1872 1878	1862	
Silurian.....	...	...	...	1854	.....	.....	...	...	1868 1871 1872 1878	1862, 1863 1864, 1866	
Cambrian	...	...	...	...	.....	.....	...	...	.....	1864	

Note.—The numbers in the above List refer to the Volumes issued for those Dates.

STRATIGRAPHICAL TABLE *exhibiting the* BRITISH FOSSILS *already figured and described in the* ANNUAL VOLUMES (1847—1878) *of the* PALÆONTOGRAPHICAL SOCIETY (*continued*).

	MOLLUSCA.				VERTEBRATA.		
	Polyzoa.	Brachiopoda.	Monomyaria, Dimyaria, and Gasteropoda.	Cephalopoda.	Fishes.	Reptiles.	Mammalia.
Pleistocene	...	1873	.....		...	.....	1864, 1867, 1868, 1871, 1877, 1878
Crag	1857	1852, 1873	1847, 1850, 1853, 1855, 1871, 1873	...	...	.....	1869
Eocene	...	1852, 1873	1852, 1854, 1855, 1858, 1859, 1862, 1870, 1877	1848	...	1848, 1849, 1856	
Cretaceous.....	...	1852, 1854, 1873	1872, 1875, 1877	1853, 1854, 1855	...	1851, 1857, 1858, 1862	
Wealden	...	... ..	.....	...	...	1853, 1854, 1855, 1856, 1857, 1862, 1871, 1873, 1875, 1876, 1878	
Oolitic	...	1850, 1852, 1876, 1878,	1850, 1853, 1854, 1872, 1874, 1875, 1877	1850, 1861, 1868, 1869	...	(Purbeck) 1853, 1858 (Kim. Clay), 1859, 1860, 1868, 1873, 1875, 1877 (Great Oolite) 1875	1870
Liassic	...	1850, 1852, 1876, 1878	1874, 1877	1863, 1864, 1866, 1868, 1878	...	1859, 1860, 1863, 1869, 1873	
Triassic.....	...	1876, 1878	.....	.....	1878	.....	1870
Permian	1849	1849, 1856	1849	1849	1849	1849	
Carboniferous ...	...	1856, 1857, 1858, 1859, 1860	.....	.....	1877		
Devonian	...	1862, 1863	.....	.....	1867, 1869		
Silurian.....	...	1865, 1866, 1868, 1870					
Cambrian							

NOTE.—The numbers in the above List refer to the Volumes issued for those Dates.

THE

PALÆONTOGRAPHICAL SOCIETY.

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VOLUME FOR 1878.

LONDON:

MDCCCLXXVIII.

MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

THOMAS WRIGHT, M.D., F.R.S. Edin.. F.G.S.,

VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÈGE; THE SOCIETY OF NATURAL SCIENCES OF NEUCHÂTEL; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH TO THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON-KINGS, AND LECKHAMPTON.

VOLUME FIRST.

PART EIGHTH.

ON THE SPATANGIDÆ AND ECHINOCORIDÆ.

Pages 265—300; Plates LXIIa, LXIII—LXIX.

LONDON:

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1878.

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Genus—EPIASTER, *d'Orbigny*, 1853.

SPATANGUS (pars), Auctorum. MICRASTER (pars), *Agassiz*.

Form oblong; test more or less elevated, often cordiform.

Antero- and postero-lateral pairs of ambulacra petaloidal and lodged in depressions of the test; the anterior are longer and more developed than the posterior pair. Poriferous zones equal in each ambulacra, composed of elongated pores shorter in the internal than in the external rows.

The single ambulacrum, lodged in a well-defined anteal sulcus, is composed of pores different from those of the antero- and postero-lateral pairs, as they are mostly round and disposed in pairs set widely apart.

The apical disc is composed of four perforated genital and five ocular plates.

Peristome near the anterior border and strongly bilabiate; the inferior lip thick and prominent.

Periprocte round or oval, situated at the posterior border, often opening in a distinct area.

No fascioles.

Tubercles well spaced out, unequal in size, crenulated, and often scrobiculated; inter-tubercular area covered with granules.

The Epiasters have been long confused with the Micrasters, which they resemble much, but differ from that genus in the absence of all fascioles. They are distinguished from Echinospatagus by their ambulacra, which are in the form of enclosed petals, by their poriferous zones, which are equal, and by their peristome, which is markedly bilabiate.

EPIASTER DE LORIOLII, *Wright*, nov. sp. Pl. LIX, figs. 1, *a*—*g*.

MICRASTER LACUNOSUS, *Morris*. Catalogue of British Fossils, 1st ed., p. 55, 1843.
HEMIASTER BUCARDIUM, *Woodward*. Mem. Geol. Surv., decade v, pl. ix, notes, 1856.

Diagnosis.—Test large, cordiform, declining anteriorly, elevated posteriorly; anteal sulcus deep, grooving the border; ambulacra much depressed. Antero-laterals curved slightly forwards and outwards, and inclined at 45°; postero-laterals shorter, curved

backwards and inwards, and inclined at 30°; posterior border obliquely truncated; vent large, oval, supra-marginal; base convex; mouth-opening in the anterior fourth; peristome bilateral.

Dimensions.—Length, antero-posterior diameter two inches and five tenths; breadth, two inches and five tenths; height, one inch and five tenths.

Description.—This fine large *Epiaster* has been long known to geologists as a fossil from the Upper Greensand of Wiltshire, as I have detected specimens in different collections made many years ago. It was erroneously identified with Parkinson's *Spatangus lacunosus*, which is a Maltese specimen, and was entered in the first edition of Morris' Catalogue as *Micraster lacunosus*. It was omitted from the second edition of that work, and described by Dr. S. P. Woodward as *Hemiaster bucardium*, from his belief that it agreed with Goldfuss' figure.

The test is large and cordiform in middle growth, and round and tumid with age, when its width and length are about equal. The vertex is at a point between the terminal portions of the postero-lateral ambulacra, from whence its horizontal profile slopes gently towards the anterior border and backwards to the abruptly truncated posterior border.

The anteal sulcus is deep and narrow, with nearly vertical walls; it grooves deeply the anterior border, fig. 1 *a*, and extends from the disc to the mouth, fig. 1 *e*.

The pores are small, biserial, closely set together, and limited to the upper half of the area, with a prominent granule between the two pores forming a pair.

The ambulacra are much depressed, circumscribed, and unequal in length and inclination; the antero-lateral are one third longer than the postero-lateral pair.

The poriferous zones are wide, of unequal length, and formed of transversely elongated pores, those in the posterior zone of the antero-lateral pair are the longest and there the pores are widest apart.

There is no true peripetalous fasciole, and the naked line which Mr. Bone mistook for this structure and figured as such appears to have been produced by friction on the sutures of the large inter-ambulacral plates forming the peripetalous area added to a certain local baldness at the terminal portions of the depressed ambulacra, so that referring to Plate LIX the student must please delete the peripetalous naked line in fig. 1 *a*, *c*, *d*, *e*, *f*; in all other respects the various figures given on this plate are admirable delineations of the form and structure of this fine *Epiaster*.

The apical disc is central; it has four perforated ovarial plates, a very small spongy body, and five oculars with distinct orbits.

The numerous small tubercles are arranged in rows in quincuncial order on the plates and the interspaces are covered besides with abundant granulations. Fig. 1 *f* represents three inter-ambulacral plates, the terminal portion of an ambulacrum, with its poriferous zones, magnified three diameters in order to illustrate this portion of the anatomy of the test.

Affinities and Differences.—The wide test, deep ambulacra, and inclined upper surface distinguish this Urchin from all its congeners; and likewise from the Micrasters with which others have been often confounded.

I dedicate this fine species to my esteemed friend M. De Loriol, the learned author of the 'Échinologie Helvétique,' whose assiduous studies in Palæontology have borne such ample fruits.

Locality and Stratigraphical Position. This species has been collected from the Upper Greensand, near Warminster and Devizes, Wilts.

EPIASTER GIBBUS, *Lamarck*, 1816. Pl. LXIII, fig. 1, *a*—*k*.

SPATANGUS GIBBUS,		*Lamarck.* Animaux sans Vertèbres, t. iii, p. 32, 1816.
—	—	*Deslongchamps.* Enc. Méthod., p. 689, pl. 156, figs. 4—6, 1824.
—	—	*Goldfuss.* Petr. Germaniæ, tab. xlviii, fig. 4, p. 155, 1824.
—	—	*Defrance.* Dict. Sc. Nat., t. l, p. 94, 1827.
—	COR-ANGUINUM,	*Woodward.* Geol. of Norfolk, pl. v, fig. 8, 1833.
—	GIBBUS,	*De Blainville.* Manuel d'Actin., pp. 203, 653, 1834.
—	—	*Grateloup.* Oursins Foss. (Dax), p. 71, 1836.
—	—	*Desmoulins.* Études sur les Échinides, p. 402, 1837.
—	—	*Edwards.* Anim. sans Vertèb., t. iii, p. 331, 1840.
MICRASTER CORDATUS,		*Agassiz.* Catal. Syst., p. 129, 1847.
—	—	*Hébert.* Études sur les Terr. Crétacés; Mém. Soc. Géol. France, 2e sér., t. v, pl. xxix, fig. 16, 1854.
—	GIBBUS,	*Desor.* Synopsis Échid. Foss., p. 365, 1858.
—	COR-ANGUINUM,	*Forbes* (pars). Mem. Geol. Surv., dec. iii, pl. x, 1850.
—	GIBBUS,	*Forbes.* In Dixon's Geol. of Sussex, p. 342, pl. xxiv, figs. 5, 6, 1850.
—	COR-ANGUINUM var. GIBBUS,	*Morris.* Brit. Foss., 2nd ed., p. 83, 1854.
—	—	*d'Orbigny* (pars). Paléont. Française Terr. Crét., t. vi, p. 207, 1855.

Diagnosis.—Test cordiform, very high, and almost conical; sides convex and carinated. Ambulacra slightly depressed; anteal sulcus shallow above and grooving the anterior border; posterior margin acuminated and truncated obliquely inwards. Vent

round, supra-marginal; base slightly convex transversely; mouth-opening very near the border, bilabiate, with prominent under lip; apical disc nearly central, and placed before the vertex.

Dimensions.—Height, $1\frac{8}{10}$ inch; length, $2\frac{3}{10}$ inch.

Description.—There has been so much difference of opinion about this Urchin that I have given full details of the anatomy of its test in Pl. LXIII.

Lamarck, who first described it, has the following diagnosis:—"Sp. cordato-abbreviatus, convexus, subgibbosus, antice retusus; vertice elato; ambulacris quinis, duplicato-biporosis; ano ovato;" and refers to the figure in the 'Encyclopédie Méthodique,' pl. 156, figs. 4—6, as the type of the form. Goldfuss gave in his 'Petrefacta' excellent figures and an accurate description. Woodward sketched a fair outline of it in his 'Geology of Norfolk,' but mistook it for the common Chalk species *Micraster cor-anguinum*. Desmoulins, De Blainville, Deshayes, Grateloup, and Desor, all retained the species as established by Lamarck. My late esteemed colleague, Professor E. Forbes, upheld Woodward's mistake, and mentioned it as a variety of *Micraster cor-anguinum* in the 'Memoirs of the Geological Survey,' Decade III, Pl. 10, whilst oddly enough he had previously described it correctly in his account of the Echinodermata in Dixon's 'Geology of Sussex.' D'Orbigny in his 'Paléontologie Française' groups *M. gibbus* with *M. cor-anguinum*, and perpetuates the old confusion I have pointed out.

If we admit that the structure and disposition of a fasciole or *fascioles* form characters of sufficient importance for the establishment of generic groups among the *Spatangidæ*, then, indeed, the Urchin under consideration is not only specifically but generically distinct from *Micraster cor-anguinum*, for, whereas all true Micrasters have a subanal fasciole, forming a ring placed around the base of the posterior border, one half of which embraces the border, the other half the base, the Urchin before us has no fasciole whatever; and this anatomical fact has been altogether overlooked both by Forbes and d'Orbigny, otherwise they would not have confused *gibbus* with *cor-anguinum*.

The build of this Urchin differs from *M. cor-anguinum* in having a flattened base, an angular ambitus, and a pyramidal upper surface, with steeply-inclined sides, the anterior portion sloping at an angle of from 40° to 50°, the posterior from 25° to 30°, and the lateral sides 35°. In half a dozen good typical specimens these measurements represent a fair average. Pl. LXIII, fig. 1, *c*, *d*, *e*.

The ambulacral areas are narrow, and their petaloidal portions not much depressed, fig. 1 *a*, *c*, *d*, *e*; the antero-lateral being one third longer than the postero-lateral pair. The poriferous zones of the petals consist of a pair of holes, the inner being rounder than those in the outer line, and they are connected by a slight depression in the plates, fig. 1 *g*. Beyond the petals the zones diverge; and in the anterior pair I have traced the holes to the ambitus, in the posterior pair they have disappeared. The anteal sulcus is feebly marked, and the single petal shorter than the anterior pair; in the petaloid

section it contains about 20 pairs of holes in each zone, and in the non-petaloidal portion of this area the small pairs of pores can be distinctly traced to the ambitus and onward to the mouth-opening, fig. 1 *e, h*. The ambulacral plates in the petaloidal portions of the areas are elongated and flat in the single area, and short, convex, and tumid in the antero- and postero-lateral pairs. There are several miliary granules on the plates in the single arc and only solitary granules on the convex surface of those in the pairs.

The inter-ambulacral areas are formed of very large plates (fig. 1 *a, c, d, e*), which on the upper surface have a conspicuous mesial suture in each of the areas. All the plates are covered with several horizontal rows of tubercles, arranged in a quincuncial manner, fig. 1 *g*, on their surface, and the inter-areolar space on the same is profusely covered with microscopic granules; fig. 1 *g* exhibits three of the inter-ambulacral and a portion of the petaloid and non-petaloid portions of the ambulacral plates, magnified three diameters; the arrangement of the tubercles and granules is likewise well delineated in this beautiful drawing. The tubercles are raised on bosses encircled by sunken areolas, each of which is surrounded by a circlet of microscopic granules, so that the surface of the test in a well-preserved specimen, such as the type I have figured, is highly ornamented.

The posterior border is a very limited space, and is truncated obliquely downwards and inwards; in its upper portion the vent is situated (fig. 1 *d*). The periprocte is large, circular, and supra-marginal, and its position in relation to the base is very well shown in fig. 1 *c* and fig. 1 *d*.

The apical disc is small in proportion to the size of the shell. It consists of four perforated ovarials and five small, heart-shaped eye-plates; the antero-lateral ovarial is much larger than the others, and extends obliquely into the centre of the disc, with the spongy body covering its surface as in fig. 1 *a*, where the relation of the disc to the petaloid ambulacra is shown, and in fig. 1 *f*, where the disc is drawn magnified eight diameters.

The base is nearly flat, and most accurately delineated in fig. 1 *b*. The course of the basal portions of the postero-lateral ambulacra are observed dividing the base into a central and lateral regions; the central extends from the lower labial prolongation backwards becoming merged in the posterior border, and is closely covered with tubercles, close-set and arranged with great regularity in this space; the lateral regions extending to the sides and anterior border have fewer tubercles, which are larger in size, but more sparse in their distribution than those which occupy the central shield. I have given a figure of the basal tubercles in fig. 1 *k*, showing the boss with its areola and circle of granules, and the perforated tubercle raised on the summit of the radiated bossal elevation. The enlargement is eight times, so that the comparative magnitude of the tubercles on the upper and under surfaces of the test of this species may be fairly estimated by comparing fig. 1 *i* with 1 *k*, and the whole in relation to the test in figs. 1 *a* and *b*.

The mouth-opening is found very near the anterior border, figs. 1 *b*, *c*, and *e*. It is largely and transversely oblong, and the lower lip is thick and much prolonged.

Affinities and Differences.—This Urchin resembles some forms of *Micraster coranguinum*, and has long been considered by many a variety of that common Chalk species. An attentive study of the anatomy of their tests will soon disclose their affinities and differences, which have already been pointed out in the introductory part of the description, and to which I refer the reader.

Locality and Stratigraphical Position.—The most typical examples of this species are found in the Upper Chalk at Harford Bridge, near Norwich, and from the Upper Chalk of Sussex, where it is very rare. The large specimen figured in 'Dixon's Geology of Sussex' is a broad and abnormal form of the species, and is the type of my late colleague's description in the text of that work.

Since this article was in type my friend Mons. de Loriol has called my attention to and given me a copy of a memoir by Dr. Clemens Schlütter ('Verh. d. Nat. Ver. Jahrg.,' xxvi, Folge 3, Bd. vi), "Fossilen Echinodermen des nördlichen Deutschlands," in which the author has published good figures and an accurate description of *Epiaster gibbus*.

Genus—MICRASTER, *Agassiz*, 1836.

SPATANGUS, pars, *Auctorum.*
MICRASTER, pars, *Agassiz.*
MICRASTER, *d'Orbigny.*
MICRASTER, *De Loriol.*

Body oval, oblong, more or less inflated; test cordiform, thin, and fragile.

Ambulacral pairs petaloidal, closed at their extremities, the anterior exceeding in length the posterior pair.

Poriferous zones equal in each ambulacra.

Holes oval or oblong, conjugated by transverse depressions.

Anterior or single ambulacrum lodged in a wide, shallow, anteal sulcus, which deeply indents the border of the test.

Pores small and round, and set obliquely in uniform pairs more or less widely apart, the distance of one pair from another increasing from the disc to the mouth.

Apical disc small, central, solid, composed of four perforated ovarial and five perforated ocular plates.

Madreporiform body small, located in the middle of the disc.

Mouth-opening transverse near the border; peristome bilabiate, with a prominent projecting under lip. Base flat or slightly convex, covered with large, regularly arranged, well-developed tubercles.

Posterior border narrow, obliquely truncated downwards and inwards, and slightly concave transversely.

Vent located in the upper part of the border under a ridge-like projection of the dorsal surface.

Periprocte oval and widely patent.

Fasciole sub-anal, forming a ring around the posterior extremity ; embracing half of the upper and half of the lower part of the border.

Tubercles perforated sparsely, distributed on the upper surface; larger and placed closer together below. All are raised on bosses with crenulated summits.

Spines small, needle-shaped, straight or bent, and enlarged and crenulated at the base.

Micraster differs from *Epiaster* in possessing a well-defined sub-anal fasciole, and from *Hemiaster* and *Periaster* by the absence of a peripetalous fasciole.

Micraster forms a leading genus of fossil Urchins, and well characterises the upper beds of the Cretaceous formation in the Anglo-Parisian, Pyrenean, and Mediterranean basins of Europe.

MICRASTER COR-ANGUINUM, *Klein*, sp., 1734. Pl. LXII, figs. 1 *a*—*l*, 3, 5 (not fig. 4).

BRONTIA vel OMBRIA,	*Plot.* Nat. Hist. Oxfordshire, p. 91, pl. ii, fig. 11, 1677.
ECHINITES PRÆTER RADIOS,	*Lister.* De Lapidibus Turbinatis, p. 224, fig. 28, t. vii, 1678.
ECHINITES CORDATUS VULGARIS,	*Llhwyd.* Lithophylac. Britannici Iconograph, p. 47, Num. 964—967, fig. 964, 1699.
ECHINOSPATAGUS CORDIFORMIS,	*Breynius.* Schediasma de Echinis, p. 62, t. v, figs. 5, 6, 1732.
SPATANGUS COR-ANGUINUM,	*Klein.* Naturalis Dispositio Echinodermatum, p. 28, t. xxiii, figs. A—D, 1734.
— —	*Klein.* Ordre Nat. des Oursins de Mer; ed. Gall., p. 100, pl. xii, figs. E, F, pl. xiii, fig. C, 1754.
— —	*Leske.* Addit. ad Kleinii Disposit. Echinid., p. 221. pl. xxiii, figs. A—D, pl. xxiii* C, and pl. xlv, fig. 12, 1778.
ECHINUS COR-ANGUINUM,	*Gmelin.* Systema Naturæ, p. 3195, No. 91, 1799.
SPATANGUS COR-MARINUM,	*Parkinson.* Organic Remains, vol. iii, p. 28, pl. iii, fig. 11, 1811.
— COR-ANGUINUM,	*Lamarck.* Anim. sans Vert., t. iii, p. 32, 1816.
— PUNCTATUS,	*Lamarck.* Ibid.
— COR-ANGUINUM,	*Deslongchamps.* Encyl. Méthod., t. ii, p. 63, 1824.
— PUNCTATUS,	*Deslongchamps.* Ibid.
— COR-ANGUINUM,	*Defrance.* Dict. Sc. Nat., p. 93, t. l, 1827.
— PUNCTATUS,	*Defrance.* Ibid.

SPATANGUS COR-ANGUINUM,	*Goldfuss.* Petrefacta Germaniæ, vol. i, p. 157, pl. xlviii, fig. 6, 1829.
— —	*De Blainville.* Dict. Sc. Nat., t. xl, p. 135, 1830.
— PUNCTATUS,	*De Blainville.* Ibid.
— COR-ANGUINUM,	*Agassiz.* Prodrom., Mém. Sc. Nat. Neuchatel, t. i, p. 184, 1835.
— —	*Desmoulins.* Études sur les Échinides, p. 402, 1837.
— PUNCTATUS,	*Desmoulins.* Ibid.
— COR-ANGUINUM,	*Agassiz.* Catal. Syst. Ectyp. foss., p. 2, 1840.
— PUNCTATUS,	*Dujardin.* In Lamk. Anim. sans Vert., 2nd ed., t. iii, p. 328, 1840.
— COR-ANGUINUM,	*Dujardin.* Ibid.
MICRASTER COR-ANGUINUM,	*Geinitz.* Charakteristik. Petref. Sächs-bohm. Kreidegebirges, p. 91,1842.
—	*Morris.* Catalogue of British Fossils, p. 54, 1843.
— —	*Agassiz et Desor.* Catal. rais. des Ech., Ann. Sc. Nat., 3e sér., t. vii, p. 23, 1847.
— —	*d'Orbigny.* Prodrome Pal. Strat., t. ii, p. 269, 1850.
— —	*Sorignet.* Oursins foss. de l'Eure, p. 59, 1850.
— —	*Forbes.* Mem. Geol. Surv., decade iii, pl. x, 1850.
— —	*Bronn.* Lethæa geognost., Kreidegebirge, p. 200, 1852.
— —	*d'Orbigny.* Paléontologie Française, Terr. crétacé, t. vi, p. 207, pl. 867 (pars), 1852.
— —	*Forbes.* Morris, Catal. Brit. Fossils, 2nd ed., p. 83, 1854.
— —	*Hébert.* Tabl. Foss. de la Craie de Meudon, Mém. Soc. Géol. de France, 2e série, t. v, pl. xxix, fig. 15, 1854.
— —	*Desor.* Synopsis des Échinides fossiles, p. 364, 1858.
— —	*Cotteau.* Échinides de la Sarthe, pl. lv, figs. 5—10, p. 326, 1860.

Diagnosis.—Test cordiform, length and width nearly equal. Upper surface more or less inflated in different specimens; enlarged and sinuous before, contracted and tapering behind; the greatest diameter at the anterior third. Upper surface convex; the anterior half declining obliquely from the disc to the anteal sulcus, and the posterior half forming a curved carinal ridge from the disc to the anal area; posterior border flat, scooped out, and inclined inwards; vent above opening under the rostrated carina. Under surface convex; anteal sulcus equally hollowed throughout, from the disc to the mouth; petaloid ambulacra unequal in length and slightly depressed; mouth-opening near the border, with a very stout under lip.

Dimensions.—Height, $1\frac{1}{2}$ inch; length, $2\frac{2}{10}$ inches; width, $2\frac{2}{10}$ inches.

Description.—This common Chalk Urchin has been long known to naturalists, and its flint moulds, collected from the Chiltern downs, were first figured by Plot in his 'History of Oxfordshire,' then by Lister and Llhwyd, and its test by Breynius, Klein, Van Phelsum,

Leske and others. It presents a great many forms which have been considered distinct species by some, but only as varieties by others. The specimen I have selected for figuring and description is a capital type of the species in the highest state of preservation, and the anatomy of the test has been carefully displayed in a series of figures in my late lamented friend Mr. C. R. Bone's best manner.

The test is cordiform, and its width and length are nearly equal; it is enlarged before and contracted behind, and its greatest transverse diameter is at the junction of the anterior with the middle third; the upper surface is inflated; from the disc to the anterior border it is obliquely depressed, fig. 1 *c*, and from the disc to the posterior border it describes a curved line which forms the summit of a carinal ridge extending to the vent and forming a rostrated process at the upper border of the periprocte; the sides are much inflated, fig. 1 *a*, and the posterior border is flat, obliquely truncated downwards and inwards, and with the rostrated carina forms an excavation which imparts a specific character to the species, which is well delineated in fig. 1 *c*.

The pairs of petaloid ambulacra are of unequal length, the anterior pair being the largest; they are not much depressed and very slightly flexed; the poriferous zones are narrow, not rounded at their extremity, and present certain characters which prevail throughout the various forms this species exhibits.

The ambulacral plates are invariably tumid, rugose, and separated by a strongly marked suture, fig. 1 *h*, magnified four diameters; whilst the general suture running down the centre of the ambulacral area is deeply depressed and grooved like fig. 1 *a*; the ridge separating each poriferous groove is also tumid and studded with a single row of five or six small close-set tubercles, fig. 1 *h*.

The single anterior ambulacrum is feebly petaloid in its upper part; its pores are set much closer together than those in the pairs, and in many specimens the grooves connecting the pores are obsolete; the pores of the inner row in the lateral ambulacra is rounder than those of the outer row, which are slightly elongated, fig. 1 *h*; the non-petaloid portion of this area is more fully developed than in the corresponding portion of the others; fig. 1 *i* shows the anterior ambulacrum. It is lanceolate, the plates are wide and irregular, each having a pair of small holes with tubercles placed between them.

The inter-ambulacral areas are formed of large plates eight to ten in each column according to the age of specimen. They attain a greater development at the base, the postero-lateral pair forming the largest portion of the region, fig. 1 *b*; the antero-lateral pair forming the anterior border, fig. 1 *a*, *e*; the carinal ridge, the anal area, the central shield of the base, with its circular subanal fasciole, and highly ornamented tubercular surface, are all formed by the single posterior area, fig. 1 *b*, *c*, *d*.

The surface of the inter-ambulacral plates is covered with highly developed tubercles on the sides and upper surface; each plate has four or five horizontal rows of them more or less regularly arranged as shown in fig. 1 *f*, where two of these plates are drawn magnified four diameters.

The plates in the ambulacral areas likewise support tubercles, but they are smaller and more sparsely distributed than in the inter-ambulacra; the relative magnitudes of the tubercles in the two areas is shown in fig. 1 *f*, where they are both drawn to a scale of four diameters. The tubercles on the sides and upper surface consist of a perforated tubercle, placed upon a crenulated boss, and surrounded by a smooth areolar space, not scrobiculated on the upper surface, but very distinctly so at the base. They become much more numerous around the ambitus, and increase in size on the basal plates of the postero-lateral inter-ambulacral areas, fig. 1 *b*. On the triangular central space extending from the fasciole to the under lip, the tubercles are arranged in well-formed rows that radiate forwards and outwards from a central tubercle and fill the entire space with close-set, regularly arranged tubercles, as shown in fig. 1 *b*; the structure of the tubercles is very well delineated in the enlarged drawing of the same, made from a portion of the base where each areolar space is seen to be surrounded by a circle of granules and the intermediate portion filled in with the same.

The tubercles supported small, needle-shaped spines, some of which are preserved on one of our specimens; of these spines a few are slightly bent near the base, fig. 5; all are marked by fine longitudinal ridges, fig. 3 (destitute of spiral ornaments), which disappear towards the apex; at the acetabulum a crenulated ring is visible. The minute spines with distinct ridges, which extend from base to apex, and which are traversed by a series of spiral depressions, fig. 4, occasionally found in the beds containing *M. cor-anguinum*, belong to *Echinothuria floris* and not to *M. cor-anguinum*.

The apical disc is small and excentral, and composed of four perforated ovarial plates, the right antero-lateral being much the largest and extending into the middle of the disc; it is covered with the madreporiform body. The five ocular plates are wedged into the angular spaces left by the ovarials; the discal elements being firmly soldered together, this portion of the test is nearly always well preserved.

The posterior border is flat, abruptly truncated, and obliquely inclined downwards and forwards. The vent occupies the upper part of this region, and opens immediately under the rostrated carina. A few small tubercles are sparsely disposed below the vent and the lower part of the space is smooth, the fasciole encircles the angle, one half passing above, the other half below the basal angle. It is well seen in most specimens, and I have given a drawing of it in fig. 1 *k*, where it is seen passing as a finely granulated band between the tubercles on the plates.

The mouth is placed very near the border, at the inferior termination of the deeply impressed anterior ambulacrum. It varies in position slightly in different specimens. The lower lip is thick and strong, and varies in the amount of projection, fig. 1 *b* and *e*.

Affinities and Differences.—This species, so long known and so often described, has nevertheless been the subject of much confusion. The older authors, as Lister and Llhwyd, appear to have been acquainted with its moulds in flint. Breynius and Klein studied its test, and the latter described it in 1734 under the name *Spatangus cor-anguinum*.

His figures are very poor, and the varieties which he has united under the name appear to comprise forms which do not properly belong to the type. Goldfuss was the first who, in 1829, gave an exact representation of the test from the able and accurate crayon of Herr Höhe. He separated it from his *Spatangus cor-testudinarium*, with which it had been united; but the authors who followed Goldfuss have forgotten the distinction pointed out by him; thus Agassiz and Desor in 1847 reunited these two species, and considered *Micraster cor-testudinarium* only as a large variety of *Micraster cor-anguinum*. Forbes in 1850, and d'Orbigny in 1853, increased the confusion, for by them nearly all the species of the White Chalk were referred to one and the same type, and *Micraster gibbus, rostratus, cordatus, cor-testudinarium, latus, armatus, brevis*, &c., successively established by different authors, were only admitted as simple varieties of *Micraster cor-anguinum*.

Professor Hébert after a careful study and comparison of the species of Micraster reunited by Forbes and d'Orbigny, arrived at an opposite determination; not only did he admit the validity of *Micraster cor-testudinarium, gibbus*, and *brevis*, but he determined two other species. The structure of the ambulacral plates is the principal character upon which M. Hébert founds the description of his species.

In his 'Synopsis des Échinides Fossiles,' published since Professor Hébert's memoir,[1] M. Desor persists in uniting *Micraster cor-testudinarium* to *M. cor-anguinum*, and admits under reserve *M. Brongniarti*, Héb., and *M. Desori*, Héb., proposed therein with such diverse opinions about the true characters of this old fossil. When M. Cotteau was about to describe the species in his classical work on the 'Échinides du département de la Sarthe,' he determined to study the species anew, and for this purpose collected all the necessary documents for reference and numerous specimens for comparison, and says, "Without adopting entirely the conclusions of M. Hébert we believe, nevertheless, that there exists among the Micrasters which d'Orbigny has confounded under the same denomination four species very distinct, viz."

"1st. The *Micraster cor-testudinarium*, Goldfuss," admirably figured and described by Cotteau.

"2nd. *Micraster gibbus*, Agass. *Spatangus gibbus*, Lam." (*Epiaster gibbus* of this work.) "Well represented in the 'Atlas de l'Encyclopédie Méthodique,' pl. clvi, figs. 4—6, and remarkable for its elevated conical form, its long straight ambulacra, its large, flat under surfaces, truncated posterior border, with its vent placed low down near the angle." Remarkable also, I may add, for the want of the subanal fasciole, which has been overlooked by Forbes, d'Orbigny, and Cotteau: so that assuming the presence, absence, or character or number of the fascioles to afford characters for generic division, this species would not belong to the Micrasters at all.

"3rd. The *Micraster Brongniarti*, Hébert, figured for the first time by Brongniart in his 'Fossils from the Environs of Paris' under the name *Micraster cor-anguinum*, and

[1] 'Etude sur les Terr. crétacés, Mém. Soc. Géol. de France,' 2e série, tom. v, pl. xxix, fig. 19.

perfectly characterised by its sub-undulated ambitus, subconvex upper surface, its central ambulacral summit, ambitus much grooved by the single ambulacrum, and its narrow ambulacra deeply depressed. The *Micraster Brongniarti* appears to be special to the Chalk at Meudon, as but one mould has been collected near Sens."

"4th. The *Micraster cor-anguinum*, easily recognised by its cordiform outline, dilated before, acuminated behind, by its elevated and inflated upper surface, convex and rostrated in the posterior region, with narrow and shallow petaloid ambulacra; its ambulacral plates shorter and deeper than in its congeners, and by its excentral apical disc placed in the direction of the posterior border."

Locality and Stratigraphical position.—It is found in all the Upper Chalk districts of England, and is common in Kent, Sussex, and Norfolk. It was recorded by General Portlock from the Chalk of Magilligan, County Derry, Ireland.

Foreign Distribution.—This Urchin is one of the most characteristic of the Upper White Chalk, equivalent of the '22e Étage Sénonien,' d'Orbigny. According to that author it has been collected in the *Anglo-Parisian basin* at Meudon (Seine-et-Oise); Beauvais (Oise); in the Somme; in the Ardennes at Retheil; in the Seine-Inférieure, at Ciqueport, Étretat, Fécamp, Dieppe, Tréport; in the Yonne at Sens, Seigneley, Joigny, Villeneuve-sur-Yonne; in the Eure, at Châteaudun; in the Sarthe, at Saint-Frambault, Roches, Vendôme; in the Loir-et-Cher, at Couture, Villiers, Blois; in l'Indre-et-Loire, near Tours.

In the Pyrenean basin at Périgueux (Dordogne), at Moutiers, Cognac (Charente); at Mirambeau, Coze, Meschers, Saintes (Charente-Inférieure); at Tercis, Rivière, near Dax (Landes); at Mauléon, Magnoac (Hautes-Pyrénées); at Bidart (Basses-Pyrénées). *In the Mediterranean basin* at Soulage, Songraigne (Ande); at Ayglun, Mers, Beausset (Var); and in Scandinavia, Germany, Switzerland, and Belgium in the same geological horizon.

MICRASTER COR-BOVIS, *Forbes*, 1850. Pl. LXII A, figs. 1, 2 *a—d.*

MICRASTER COR-BOVIS, *Forbes*. In Dixon's Geol. of Sussex, pl. xxiv, figs. 3, 4, p. 342, 1850.
— — *Forbes*. Mem. Geol. Surv., decade iii, note, pl. x, 1850.
— — *Forbes*. In Morris' Cat. of Brit. Foss., 2 ed., p. 83, 1854.
— — *Desor*. Synopsis des Échinides Foss., p. 367, 1858.

Diagnosis.—Test large, ovate, slightly cordate, broadest in the region of the antero-lateral ambulacra. Posterior border obtusely subtruncated. Dorsal surface depressed. and slightly elevated in the anterior region above the rest of its surface. Apical disc excentral, nearer the anterior border. Anteal sulcus shallow, petaloid ambulacra short, unequal in length, and slightly depressed. Base convex, vent in the middle of the obtusely sub-truncated border.

Dimensions.—Length three inches; breadth two inches and seven twelfths; height one inch and nine twelfths of an inch.

Description.—My late esteemed colleague in this work, Professor Edward Forbes, gave the following note upon this Urchin in Decade III of the 'Memoirs of the Geological Survey,' in his note on allied species of British species of Micrasters :—"I have given an account of it in Dixon's work on the 'Geology of Sussex,' where it is excellently figured. I have there named it *Micraster cor-bovis*. It is usually a larger and longer species than *cor-anguinum*, and its petaloidal ambulacra are more deeply impressed and much shorter in proportion to the body. The shape is ovato-cordate, the curve of the sides from the front of the antero-lateral ambulacra to the anal extremity being but slight, its chief swelling being near the anus, and not on a line with the postero-lateral ambulacra as in *cor-anguinum*. The back is more equally depressed than in the depressed variety of the last-named species. The mouth is much smaller comparatively, and the post-oral spinous space, though much longer, in consequence of the elongation of the hinder portion of the test, is nevertheless proportionally broader. The tubercles of the plates, whether dorsal or ventral, are much smaller and more scattered. Besides all these comparative characters, there is the positive one that in *cor-bovis* the ambulacral plates, instead of being tumid, are smooth and plain, as are also the ridges separating the sulcations of the pairs of pores in the petaloidal ambulacra. The ambulacral spaces are wider than the breadth of any of the sulcations."

It will be more satisfactory if I here insert Forbes' note from the work referred to:

"The body of this fine and large *Micraster* is ovate and slightly cordate, broadest in the region of the antero-lateral ambulacra. The posterior end is obtusely subtruncated. The dorsal surface is depressed and but slightly elevated in the anterior region above the rest of its surface.

"The ovarian circle is placed nearer the anterior than the posterior end. The frontal groove is shallow. The lateral ambulacra are placed in gentle depressions.

"The postero-lateral ambulacra are very short, and little more than half the length of the antero-laterals. There are about thirty pair of pores in each row in the latter and about seventeen in each row in the former. The larger tubercles of the dorsal plates are much scattered and minute in proportion to the size of the shell. The interstices are minutely granulated.

"The areolated tubercles of the ventral surface are also proportionally small. The post-oral spinous space is triangularly lanceolate."

Affinities and Differences.—This species resembles *M. breviporus*, of which it has long appeared to me to be a gigantic variety.

Locality and Stratigraphical Position.—Dixon's type was collected from the White Chalk, Sussex, others are found at Charing, Kent, and some fine specimens in the Woodwardian Museum, Cambridge, were obtained from Balsham, near Cambridge; it occurs low down in the White Chalk.

MICRASTER BREVIPORUS, *Agassiz*, 1840. Pl. LXII A, fig. 3 *a—b*.

MICRASTER BREVIPORUS,		*Agassiz.* Cat. Ectyp. Foss. Mus. Neo., p. 2, 1840.
—	—	*Agassiz et Desor.* Cat. raisonné des Échinides, p. 130, 1847.
—	—	*d'Orbigny.* Prodrome, t. ii, p. 270, 1850.
—	—	*Sorignet.* Oursins de l'Eure, p. 62, 1850.
—	LESKEI	*d'Orbigny.* Paléont. Française Ter. Crétacés, tom. vi, p. 215, pl. 869, 1853.
—		*Desor.* Synopsis des Échinides Foss., p. 366, 1858.
—	—	*Coquand.* Synopsis des Foss. des Charentes, p. 134, 1860.
—	—	*Cotteau.* Cat. des Échinid. de l'Aube, p. 34, 1865.
MICRASTER BREVIPORUS,		*Hébert.* Comp. rend. de l'Institut. 25 Juin, 1866.
—	—	*Schlönbach.* Beiträg. des Grünsandes von Rothenfelde, p. 14, 1869.
—	—	*De Loriol.* Echin. Helv. Échinides Crétacées de la Suisse, 2me partie, p. 369, pl. xxxi, fig. 5, 1873.

Diagnosis.—Test largely cordiform, rounded and grooved before, contracted behind and truncated at the posterior border. Upper surface uniformly convex, declining a little more anteriorly than posteriorly, with a prominent carina between the apical disc and posterior border; base convex, ambitus slightly undulated, rounded, and inflated.

Dimensions.—Antero-posterior diameter $1\frac{9}{20}$ inch; transverse diameter $1\frac{4}{10}$ inch; height $1\frac{1}{4}$ inch.

Description.—The test of this Urchin has a cordiform shape; it is rounded and slightly grooved anteriorly, and tapers gently to the posterior border, which is truncated downwards and a little inwards. The upper surface is depressed and uniformly convex, and declines a little more to the anterior than the posterior border; a prominent carina more or less elevated in different individuals extends backwards from the apical disc to the summit of the periprocte, and divides into two ridges, which descend on each side of the vent towards the lower part of the posterior border, where they disappear near the fasciole.

The ambulacra are short and straight, very unequal in length, and slightly depressed. The anterior single ambulacrum is lodged in a sulcus, which grooves the anterior border and extends to the peristome; its pairs of pores lie wide apart, and are nearly obsolete. The anterior pair are large and divergent; they occupy well-marked depressions, and their poriferous zones consist, in one of my specimens, of 30 pairs of holes, each having a connecting groove between the holes. The posterior pair are slightly bent and directed backwards, and are about two thirds the length of the anterior pair. The pores are similar in structure, and there are 18 to 20 pairs in each zone. The ambulacral plates are concave, smooth, and plain, those of the single area alone carrying miliary granules.

This structure of the ambulacra forms a good diagnostic character between this species and *M. cor-anguinum*.

The apical disc is very small, and lodged in a valley formed by the confluence of the apices of the five ambulacra; the madreporiform tubercle occupies the centre, surrounded by four ovarial holes, the posterior pair being wider apart than the anterior pair; the culminating summit of the upper surface being immediately behind the disc.

The periprocte is situated at the upper part of the obliquely truncated posterior border, and its position is persistently the same in all the six specimens before me.

The base is flattened, the portion between the peristome and anterior border is slightly hollowed out. The plastron is wide and filled with large close-set tubercles, these radiate in regular rows from a point rising near the middle of the fasciolar line; the lateral portions slope away to the ambitus; the valleys between indicate the course of the basal portions of ambulacra between the border and the mouth, which is situated at a short distance from the anterior sulcus, and is bilabiate, and surrounded by a rosette of pores and tubercles very regularly arranged in the small specimen figured in 3 *b*.

Affinities and Differences.—Micraster breviporus, which has long been considered to be a variety of *M. cor-anguinum* and of *M. cor-testudinarium*, is distinguished from them by its outline, which is more elongated and depressed, tapering at the sides, and less acuminated posteriorly; its upper surface is more uniformly convex, its ambulacral summit is excentral and placed forwards, and its petaloidal ambulacra are shorter and less depressed, and the ambulacral plates are smooth and not tumid as in *M. cor-anguinum*.

Micraster laxoporus, d'Orb., has the summit more central, the ambulacra much more depressed, the anterior half of the upper surface more declined, and the posterior half more strongly carinated. I have compared my specimens from Brighton and Norfolk with a type-specimen kindly given me by my excellent friend M. De Loriol, which was collected at St. Julien du Sault (Yonne); from the "étage Sénonien," equal to our White Chalk. M. De Loriol[1] says, "In 1837 M. Desmoulins gave the name of *Spatangus Leskei* to the Urchin figured by Klein under the name *Spatangus cor-anguinum*, var. *Norvagicum* and var. *productum*, which differs really from the true *Spatangus cor-anguinum*. D'Orbigny and other authors have referred to this *Micraster* (*Spatangus Leskei*) the species named by the late Professor Agassiz *Micraster breviporus*. Recently M. Hébert having been able in Denmark to examine the original specimens of the species which Klein had figured under the name *Sp. cor-anguinum*, var. *Norvagicum*, has recognised that it differs in reality from *Micr. breviporus*, and that it ought to be separated, and continue to bear the name *Micr. Leskei*, which appears to be a form special to the Upper Chalk of the north of Europe.

Locality and Stratigraphical Position.—My specimens of this species have been collected from the Upper Chalk of Brighton, Sussex; Balsham, Cambridge; and from the

[1] 'Paléontologie Suisse Échinides Cretacés,' p. 370.

Upper Chalk near Norwich, out of the same terrain that yielded *Cardiaster granulosus*, *Card. excentricus*, and *Epiaster gibbus*.

In France it has been collected from the White Chalk at Fécamp, Étretat, and Dieppe, the environs of Beauvais, Méru (Oise); of Vervins and La Capelle (Aisne); of Andelys, Caussols (Var); of St. Julien du Sault (Yonne).

In Switzerland (according to De Loriol) from the Seewerkalk of Sentis (Appenzell); the Grands Troncs near Semsales (Fribourg), Étage Sénonien.

Genus—ECHINOSPATAGUS, *Breynius*, 1732.

ECHINOSPATAGUS (pars), *Breynius*, 1732.
SPATANGUS (pars), *Klein*, 1734.
SPATANGUS (pars), *Lamarck*, 1816.
TOXASTER (pars), *Agassiz*, 1840.

Body cordiform, more or less inflated at the upper surface, and in general flattened at the base.

The pairs of ambulacra petaloidal, unequal in length, always large, and lodged in depressions of the test; poriferous zones wide and slightly unequal in the anterior pair; pores in the form of narrow slits, those of the outer being longer than those of inner rows; the anterior poriferous zones are longer than the posterior. The single ambulacrum is lodged in a wide, deep, anteal sulcus, its poriferous zones are narrow and equal with each other, and the holes are smaller and placed closer together than the pores in the pairs.

The apical disc is compact and solid, composed of four perforated ovarial plates and five small oculars, minutely and finely perforated; the madreporiform body extends into the centre of the disc.

The mouth-opening is situated near the anterior border, and the peristome is small and subpentagonal.

The vent is situated in the upper part of the posterior border, and the periprocte is oval.

The tubercles, of various sizes, crenulated and scrobiculated, are placed in two or three irregular rows on the plates; they are most numerous at the anterior border and around the ambitus, and are sparsely scattered on the base; the surface of the plates is likewise covered with a very fine close-set miliary granulation.

The absence of fascioles from all parts of the test distinguishes this genus from *Hemiaster*, with which it has been often confused. The type-species so common in the Neocomian strata of France and Switzerland was first figured by Breynius as *Echinospatagus cordiformis*.

It was afterwards figured and described by Agassiz as *Holaster complanatus*, and subsequently separated from that group to form the type of his genus *Toxaster*. As this corresponds with the *Echinospatagus* of Breynius, the laws of priority demand the restitution of the original name, however much we may regret these changes of nomenclature.

ECHINOSPATAGUS MURCHISONIANUS, *Mantell*, 1835. Pl. LX, figs. 1, *a*—*i*, and Pl. LXIV, fig. 1.

SPATANGUS MURCHISONIANUS, *Mantel*. Geol. Trans., 2 ser., vol. iii, p. 210, 1835.
— — *Desmoulins*. Tableau des Échinides, p. 412, 1837.
MICRASTER MURCHISONI, *Morris*. Catalogue of Brit. Fossils, p. 55, 1843.
— — *Bronn*. Index Palæontologicus, p. 724, 1848.
HEMIASTER INÆQUALIS, *Forbes*. Morris's Catalogue of Brit. Foss., 2 ed., p. 81, 1854.
— MURCHISONIÆ. *Forbes*. Mem. of Geol. Surv., decade v, pl. ix, 1856.
— — *Desor*. Synopsis des Échinides Foss., p. 369, 1857.
— MURCHISONIANUS, *De Loriol*. Échin. Helv. Cretacés, t. ii, p. 374, pl. xxxii, figs. 4—6, 1873.

Diagnosis.—Test cordiform, often much inflated, length and breadth nearly equal; round, and largely grooved before, contracted behind, and obliquely truncated on the posterior border. Upper surface convex, declining to the anterior side, and having an obtuse carina on the single inter-ambulacrum; anteal sulcus wide and deep; the pairs of petaloid ambulacra unequal in length, and forming deep depressions on the upper surface, periprocte oval, opening high on the border. Ambulacral summit excentral, posterior to the disc.

Dimensions.—A. Height, $1\frac{4}{10}$ths inch; long., $1\frac{7}{10}$ths; lat., $1\frac{7}{10}$ths.
B. Height ?; long., $1\frac{8}{10}$ths; lat., $1\frac{7}{10}$ths.
C. Height, $\frac{9}{10}$ths; long., $1\frac{4}{10}$ths; lat., $1\frac{4}{10}$ths.
D. Height, 1; long., $1\frac{3}{10}$ths; lat., $1\frac{3}{10}$ths.

Description.—I have given the dimensions of four typical specimens of this Urchin to show its relative proportions. A, the figured specimen, belongs to the British Museum, and B, C, D are in my cabinet. A is a very globose form, and B and C are fair types. In all the specimens the test is very well preserved, and there is no trace of a peripetalous fasciole on any one of them, so I have removed it from the Hemiasters and placed it in the genus *Echinospatagus*.

Professor Edward Forbes studied the specimens of this Urchin in the British Museum, and recorded his measurements in the following memorandum. Further, he noted that

they differed from each other considerably in form, and in degree of depth of the dorsal ambulacra and the number of the pores in the zones.

	A.	B.	C.
Length	$1\frac{8}{10}$	$1\frac{1}{12}$	$1\frac{1}{24}$.
Breadth	$1\frac{8}{12}$	$1\frac{2}{12}$	1.
Height	$1\frac{3}{12}$	$0\frac{11}{12}$	$0\frac{8}{12}$.
Anterior single ambulacrum . . .	28 pairs	26	24.
Antero-lateral pair „ . . .	43 pairs	36	30.
Postero-lateral pair „ . . .	20	22	16.

The anteal sulcus in which the single ambulacrum is lodged is deep, wide, finely granulated and tuberculated. The pairs of pores are arranged on the sides of the area in single files, and the pores forming a pair are separated from each other by distinct tubercles.

The antero-lateral pair are doubly flexed, and the postero-lateral pair, slightly bent, are about half their length. The floors of all the areas are nearly smooth, and the pores, with their small transverse slits in the zones, are set at short distances apart. The portions of the test between the petals form obtuse eminences near the apical disc, that body reposing at the confluence of the five valleys. On these inter-ambulacral elevations the tubercles are more numerous and set closer together than on other portions of the upper surface, fig. 1 *a* and fig. 1 *c*.

The apical disc is small, and composed of four perforated, ovarial plates; the right antero-lateral is the largest, and supports the madreporiform tubercle on its surface. The five ocular plates are very small, fig. 1 *g*.

The surface of the plates is finely granulated, among which there are developed many well-formed tubercles; these become more numerous on the sides, they increase in size and number at the ambitus, and are large and set closely together at the base, on the plastron of which they are very conspicuous, fig. 1 *b*.

Mr. Bone copied fig. 1, Pl. LX, from Decade V, pl. ix, 'Memoirs of the Geol. Survey.' In this figure, drawn under the direction of Professor Forbes, a portion of the surface adjoining the right postero-lateral ambulacrum was magnified to show the diffused condition of the fasciole. As I have carefully examined many very good tests of this species without observing such a structure, I am convinced that a mistake was committed, which my friend unfortunately imported into Pl. LX, fig. 1 *f*, of this work, as no true fasciole exists in this species.

The base is flat or rounded, and the peristome situated at the anterior fourth of the under surface; the tubercles on this region are very large, they are raised upon crenulated bosses, and their summits are perforated; the areola is surrounded by a chain of granules, which completely incircle the areolar boundaries (fig. 1 *i*).

Affinities and Differences.—This Urchin is well characterised by its large and deep anteal sulcus, its bi-flexed antero-lateral ambulacra, the small postero-lateral pair, and

the very excentral position of the ambulacral summit, which is situated behind the centre of the upper surface (fig. 1).

Locality and Stratigraphical Position.—This species is found in the Upper Greensand of Blackdown, Devon, where it is the only Urchin of frequent occurrence, and I have no record of its discovery in any other Upper Greensand locality.

ECHINOSPATAGUS COLLEGNII, *Sismonda*, 1843. Pl. LXIV, fig. 4.

TOXASTER	COLLEGNII,	*Sismonda.* Sugli Echini foss. del Contado di Nizza, p. 21, pl. i, figs. 9—11, 1843.
—	—	*Agassiz et Desor.* Cat. raisonné des Échinides, p. 132, 1847.
—	BRUNNERI,	*Merian.* In Desor's Synopsis foss. Échinides, pl. xl, figs. 2—4, p. 354, 1857.
ECHINOSPATAGUS	COLLEGNII,	*d'Orbigny.* Pal. Française, Ter. Crétacé, t. vi, p. 169, pl. lcccxlvi, 1853.
—	—	*Cotteau.* Échinides des Pyrénées, p. 52, 1863.
—	—	*Cotteau.* Échinides de l'Yonne, pl. lxiv, fig. 11, t. ii, 1865.
—	—	*Ooster.* Synop. Échin. Suisse, pl. xxv, fig. 8, 1865.
—	—	*De Loriol.* Échin. Helv. Crétacés, t. ii, pl. xxx, figs. 1—5, p. 350, 1873.

Diagnosis.—Test largely cordiform ; a little polygonal ; rounded, flattened, and slightly depressed anteriorly ; contracted behind and obliquely truncated on the posterior border. Upper surface convex, inflated at the posterior half, and much declined from the apical disc to the anterior border. Highest point at the ridge behind the apical disc. Posterior border quadrate, high, strongly and obliquely truncated. Base feebly convex in the region of the plastron, and depressed near the mouth. The lateral parts of the ambitus inflated.

Dimensions.—Length 2 inches and 2 tenths ; breadth 2 inches and 1 tenth ; height 2 inches.

Description.—This large fine Urchin was given to me several years ago by my late lamented friend Dr. S. P. Woodward, with the remark that it was said to have been collected from the Upper Greensand, Wiltshire, but the species was unknown to him, so he begged me to figure and describe it when I came to the group.

The test is large, cordate, and slightly polygonal, much elevated behind, and sloping from the summit to the anterior border.

The single ambulacrum is lodged in a large, wide, anteal sulcus, deeper above than at the anterior border, which it depresses only feebly ; its poriferous zones are narrow ; the pores are nearly equal in size, and set obliquely in pairs.

The antero-lateral ambulacra are subpetaloidal, unequal, and lodged in considerable depressions of the test. The anterior pair are the largest, and slightly flexed. The poriferous zones are unequal in width, the inner being the narrowest. The external zone is nearly as wide as the interporiferous space. The pores in both rows are nearly equal in size, and are each connected with slitlike depressions of the test. The posterior pair are shorter than the anterior. They are nearly as wide and diverge at an angle of 45°; their poriferous zones are nearly equal, and a considerable horizontal ridge separates the pair. The plates of the test are sparsely provided with small perforated tubercles, which are all raised upon crenulated bosses and surrounded by circular areolas, and the intertubercular surface is covered with a fine close-set microscopical granulation.

The apical disc is excentral, placed nearer the posterior than the anterior border, in a depression at the ambulacral summit; from this point the test developes a ridge which extends to the posterior border, and the highest point of the test is found one quarter of an inch behind the apical disc.

The posterior border is very much elevated; it appears to have a quadrate form, is sharply truncated, and almost vertical. This portion of the test is unfortunately broken, and it is from the remaining outline that the diagnosis is made. The vent was placed high up on the border, but only one side of the periprocte remains to indicate the position of that opening.

The base is flattened in the region of the plastron; it is slightly convex, and near the oral region is concave. The mouth-opening, situated at the junction of the anterior with the middle third, is transversely oval or subpentagonal; the tubercles on the base are larger than those on the upper surface. On the plastron they radiate from a central point near the posterior border, and have a very symmetrical arrangement on the anterior half; around the mouth they are larger and more sparsely distributed, whilst around the anterior border and the ambitus they are again more numerous.

Affinities and Differences.—I have grave doubts about this Urchin being a British fossil. The matrix differs from the rock in Wiltshire, which usually yields the Upper Greensand fossils of that county, and therefore I record it with reservation; it certainly is the *E. Collegnii* of Sismonda so well figured by Désor in plate 40, figs. 2 to 4, of his admirable Synopsis. Unfortunately I have no authentic specimen of this species with which to compare it, although I have no doubt as to its identity with the form referred to.

Stratigraphical Position.—Said to have been collected from the Upper Greensand of Wiltshire. I have no confirmatory evidence of the fact, and give it with proper reservation.

ECHINOSPATAGUS RENEVIERI, *Wright*, nov. sp. Pl. LXXV, fig. 1.

Diagnosis.—Test cordate, much inclined and depressed, the antero-posterior equalling the transverse diameter; ambulacral pairs petaloidal, unequal in length and structure, and lodged in slight depressions. Anterior pair much flexed; poriferous zones nearly equal, the inner a little narrower than the outer row; posterior pair short, curved; zones equal. Ambulacrum wide, lodged in a deep depression. Test elevated in posterior half and tapering behind to a point; anterior half sloping rapidly to anterior border; base flat.

Dimensions.—Length 1 inch and 4 tenths; transverse diameter 1 inch and 4 tenths; height 8 tenths of an inch.

Description.—This Urchin was catalogued by the late Dr. Fitton as *Holaster complanatus* in his lists of fossils from the inferior beds of Lower Greensand exposed at Atherfield, Isle of Wight. A careful examination of all our Neocomian Echinides, however, has proved that, although *H. complanatus* forms a leading fossil in the Lower Neocomian strata of France and Switzerland, it has never yet been found in England. I have searched carefully most of the public and private collections to find an English specimen, but hitherto without success. Any so-called examples that I have found in the cabinets of my friends were in reality foreign specimens purchased from dealers.

The outline of *E. Renevieri* is peculiar, it being as broad as it is long, and terminating behind in a pointed process. This character at a glance distinguishes it; but when added to others which I shall now point out it renders the difference wider at each step of the demonstration.

The ambulacral pairs are petaloidal and lodged in depressions, whereas in *H. complanatus* they are superficial. The anterior pair are gently flexed, and the poriferous zones are nearly of the same width; the posterior pair are short and curve inwards, and have equal-sized poriferous zones. The ambulacrum is lodged in a wide anteal sulcus, which is deeper above than at the border. The poriferous zones consist of equal-sized holes placed in oblique pairs.

The apical disc is small, and the ambulacral summit excentral; it is much nearer the posterior than the anterior border, and the highest point in the test is on an elevation immediately behind the apical disc. The posterior third of the upper surface is considerably elevated, and the two anterior thirds slope gradually to the border, which imparts a marked character to the test.

The posterior border is narrow and obliquely truncated downwards and inwards. It is unfortunately covered up with a very hard matrix, which cannot be removed without risk to the specimen.

The base is flat and partially covered, and the position of neither the mouth-opening nor the vent is shown.

Affinities and Differences.—It certainly resembles some specimens of *Toxaster complanatus*, but differs from all in the form of the test, being as broad as it is long ; its greatest transverse diameter is about the middle of the test. From this point the anterior portion of the ambitus maintains its rounded outline, whilst the posterior portion rapidly contracts to form the narrow truncated posterior border.

The pairs of petaloidal ambulacra are lodged in depressions of the test, whilst they are quite on the general surface without depressions in *T. complanatus*. The conical elevated portion of the upper part of the posterior border is likewise very different from the broadly truncated posterior border in *T. complanatus*. For these reasons I have grouped it with the *Echinospatagi*, and dedicated the species to Professor E. Renevier, of Lausanne, who collected the specimen at Shanklin, Isle of Wight, and gave it to our mutual friend Monsieur De Loriol, to whose cabinet it belongs.

Locality and Stratigraphical Position.—Found in the inferior beds of Lower Greensand at Shanklin, Isle of Wight, in the hard grey sandy rock with numerous oolitic grains of silicate of iron, and which contains fine specimens of *Gryphæa sinuata* and *Ostrea carinata*, with the Echinides *Clypeopygus Fittoni*, Wr., and *Enallaster Fittoni*, Forb. It is, therefore, derived from one of the richest Urchin-beds of the Neocomian series in the Isle of Wight.

ECHINOSPATAGUS QUENSTEDTII, *Wright*, nov. sp. Pl. LXXV, fig. 2.

Diagnosis.—Test cordate. Upper surface convex, very much declined, length and breadth nearly equal. Ambulacral pairs unequal, lodged in shallow depressions. Anterior pair lanceolate, not flexed ; form an angle of 40°. Posterior pair short ; form an angle of 45°. The poriferous zones of both pairs equal. Ambulacrum long, anteal sulcus shallow, poriferous zones not longer than the anterior pair, only grooving the anterior border very little. Ambulacral summit excentral, situate at the junction of the posterior with the middle third. Posterior border truncated concavely. Flanks sloped inwards. Base small, flat ; mouth-opening transversely oblong near the ambitus. Vent high up in the border ; periprocte oblong ; upper point extending to the beak-like process of the test.

Dimensions.—Length 2 inches and 1 tenth ; breadth 2 inches and 2 tenths ; height at vertex 1 inch and 2 tenths.

Description.—This Urchin was collected from the fine sandy calcareo-micaceous beds of Lower Chalk or Upper Greensand in Wiltshire ; it is always more or less completely denuded of the plates of its test, and is found in the form of moulds. The fineness of

the matrix fortunately produces a very sharp cast of the interior, and as the shell was very thin the outline of its structure is very well preserved.

The ambulacral pairs form quite a "crux Andreæ" on the convex surface of the highly inclined dorsal surface. They were lodged in very shallow depressions, and pass nearly straight out from the summit to the ambitus. The anterior pair are lanceolate and moderately long, and the posterior pair short, extending half the distance between the disc and the border. The poriferous zones in both pairs are nearly equal. The single ambulacrum lies in a shallow anteal sinus, which scarcely grooves the anterior border.

The ambulacral summit is extremely excentral, the disc being near the junction of the posterior with the middle third.

The upper surface is convex and very much inclined. The posterior third is the highest, and the two anterior thirds slope sharply down to the border forming an angle of 20°.

The anterior border is thin, the sides inflated, and bevelled away towards the base and posterior border, which is truncated concavely, and has a portion of the upper surface overhanging it above. In this beak-like projection the vent is situated. The periprocte is oval, the upper end reaching near to the border.

The base is flat. The mouth-opening is situated near the border, and the peristome is narrow and transversely oval; the plastron is a little convex near the border.

Affinities and Differences.—This species resembles *E. Renevieri* in its cordiform outline and highly inclined upper surface. It differs, however, in the shallowness of its ambulacrum and in the absence of depressions for the petaloidal ambulacra, which are straight in *E. Quenstedtii* and flexed in *E. Renevieri*.

Locality and Stratigraphical Position.—The only two specimens I have obtained were collected from the fine marly micaceous beds of the Upper Greensand of Wiltshire.

I have dedicated this species to Professor Aug. Quenstedt, of Tübingen, whose magnificent works on the Cephalopoda, Echinodermata, and 'der Jura' of Würtemburg have so greatly advanced the palæontology of the Jurassic Formations.

Genus.—Enallaster, *d'Orbigny*, 1853.

Hemipneustes, *Forbes*, 1852 (non Agassiz, 1836).
Toxaster, *Roemer*, 1850 (non Agassiz).
Enallaster, *De Loriol*, 1873.

Test more or less cordiform.

Ambulacral summit subcentral.

Ambulacral pairs subpetaloidal, unequal, and depressed.

Poriferous zones in the anterior pair unequal. The posterior zones are much larger and wider than the anterior zones. In the small short pair of posterior ambulacra the poriferous zones are equal.

The anteal sulcus wide. Single ambulacrum, one third wider than the laterals, has narrow poriferous zones, in which each pair of holes are set well spaced out and disposed very oblique to each other; a small tubercle rising from the surface of the partition wall between the pores divides them, and developes an ornamental beaded line on each side of the area.

Apical disc small, compact, with four perforated ovarial and five perforated ocular plates.

Mouth near the anterior border. Peristome subpentagonal, with well-defined margin.

Vent in the middle of the truncated posterior border. Periprocte oval, with well-defined margin.

Enallaster Fittoni, *Forbes*, 1852. Pl. LXV, figs. 1 *a—f*, 2 *a—c*.

Hemipneustes Fittoni, *Forbes*. Mem. Geol. Surv., decade iv, pl. v, note, 1852.
— — *Forbes*. *Morris*. Catalogue of British Fossils, 2 ed., p. 82, 1854.
Enallaster Fittoni, *Désor*. Synopsis des Échinides fossiles, p. 357, pl. xl, figs. 5—7, 1857.
— — *Jaccard*. Jura Vaudois et Neuchatelois, p. 134, 1869.
— — *De Loriol*. Échin. Helv. Crétacés, t. ii, p. 359, pl. xxx, fig. 9, 1873.

Diagnosis.—Test oval, cordiform, rounded and sinuous before, contracted behind,

and obliquely truncated posteriorly. Upper surface convex, elevated, and declining towards the anterior border; base flat, with peristomal depression. Sides rounded and inflated, ambulacral summit excentral, and posterior; periprocte oval, situated high up in the border.

Dimensions.—Antero-posterior diameter one inch and $\frac{4}{10}$ths; height, one inch; transverse diameter, one inch and $\frac{5}{20}$ths.

Description.—The test is sometimes cordiform, tapering slightly from the anterior third to the posterior border; in other specimens it is oval, its greatest diameter being about the middle of the ambitus, from whence it diminishes anteriorly and posteriorly. The anteal sulcus is shallow, and the pairs of ambulacra are unequal in length and not much depressed (fig. 1 *a*).

The antero-lateral pair are only partially petaloid, they are long, wide, and depressed in their upper third, are arched above and divergent below. The poriferous zones are very unequal, the anterior are very narrow and composed of small, oblong, almost equal pores, each pair being disposed obliquely circumflex (fig. 2 *c*).

The posterior are much larger, and formed of elongated pores, of which the external are nearly twice as long as the internal series, and there are about 36 pairs of pores in the petaloid portion of each row. The postero-lateral ambulacra are much shorter and more symmetrical in structure, and their poriferous zones are nearly equal; there are about 16 pairs of pores in the petaloid parts of each row. The anterior single ambulacrum is lodged in a shallow anteal sulcus, and is wider than the antero-lateral pair. It preserves a nearly uniform width throughout, and is composed of small plates, which become gradually contracted vertically throughout its upper half (fig. 2 *b*), a character which appears to be generic rather than specific in all the Enallasters that have passed through my hands.

In the lower half of the areas the plates are large, square, or oblong; they are each perforated near their lower and outer corners by a pair of minute approximated pores. In the upper half of the area the plates become narrow, and the poriferous zones are here very conspicuous; each pair of pores is set obliquely in a kind of circumflex manner with a prominent tubercle marking the divisional partition between them (fig. 2 *b*), a singular character which was not well shown in the figured specimen, although it is well marked in others in which the tubercles of the test have been preserved. The surface of the plates is covered with minute granulations, closely set together in transverse rows.

The apical disc is small and compact, the four genital plates are perforated, and the right antero-lateral extends into the middle of the disc, with the madreporiform body on its surface; the elements of the disc are closely blended with the areal plates (fig. 2 *b*).

Peristome subpentagonal and lodged in a depression; it is encircled by a smooth border, and is elongated transversely (fig. 1 *b*).

The periprocte is small and oval, and opens at the summit of the truncated posterior border, within a smooth, undefined, anal area (fig. 1 *a* and *d*).

The tubercles are very small, and developed chiefly on the sides and base (fig. 1 *b*), on the convex upper surface they are nearly absent (fig. 1 *a*); they are largest on the anterior and lateral portions of the base (fig. 1 *b*), and on the plastron they are more regularly arranged; the miliary granules are very small, and set closely together over the surface of the plates and around the tubercles, as seen in fig. 1 *f*, where two large plates and a portion of one of the ambulacral areas is magnified three diameters.

Affinities and Differences.—It is distinguished from *Enallaster Greenovii* by a smaller and narrower anteal sulcus, and by a difference in the structure of the antero-lateral ambulacra, the size of the poriferous zones, and the form of the pores therein.

Locality and Stratigraphical Position.—This species has been collected from Horse-ledge Point, near Shanklin, Isle of Wight, from beds of Lower Greensand, where it is very rare. I have found it in beds of the same age at Atherfield, and it is a leading fossil of these beds in the Island. It has been collected from the Lower Greensand at Hythe. My friend M. De Loriol gives La Presta (Neuchatel), Sainte-Croix (Vaud.), as localities in Switzerland, where it is collected from the yellowish marl belonging to the Étage Aptien inférieur.

ENALLASTER GREENOVII, *Forbes*, 1852. Pl. LXIV, figs. 2 *a—f*, 3 *a—d*.

HEMIPNEUSTES GREENOVII, *Forbes*. Mem. Geol. Surv., Decade iv, pl. v, 1852.
— — — In Morris' Catalogue British Foss., 2 ed., p. 82, 1854.
ENALLASTER GREENOVII, *d'Orbigny*. Paléont. Française, Terrains Crétacés, tome vi, p. 183, pl. 849, 1855.
— — *Désor*. Synopsis des Echinides Foss., p. 358, 1858.

Diagnosis.—Test cordiform, enlarged and sinuous before, contracted and truncated behind; upper surface convex, and declined towards the anterior border. Anteal sulcus large, and wider in the middle. Antero-lateral ambulacra long, biflexed; poriferous zones unequal; internal row formed of small, simple, close-set pores. Postero-lateral pair of short zones equal; posterior border obliquely truncated; periprocte in the upper third.

Dimensions.—Fig. 1. Antero-posterior and transverse diameters 1 inch and 4 twelfths; height 1 inch.

Fig. 2. Antero-posterior and transverse diameters 1 inch and 1 twelfth; height 8 twelfths of an inch.

Description.—This interesting Urchin has a regularly cordate outline, nearly as wide as long, rounded and sulcated anteriorly, and bluntly truncated posteriorly. Its tumidity

varies in different specimens, and the posterior is always higher than the anterior half of the test. The sides are much inflated, and the base is slightly convex (figs. 2 *a* and 2 *b*).

The anterior single ambulacrum is a third wider than the pairs. According to Forbes it preserves nearly a uniform width, and is composed of plates which become contracted vertically throughout the upper half (fig. 2 *a*). Out of the thirty-seven plates seen in each of its two series the lower seven are square or oblong and large (fig. 2 *f*). They are each perforated near their outer and lower corners by a pair of minute approximated pores. In the narrow plates above these a very curious change takes place in the avenue arrangements for the pairs of pores; all become conspicuous, are alternately approximated, and set widely apart, the latter pairs each consisting of a long outer pore and a shorter inner one (fig. 2 *f*). Inside of the pores there is a very small tubercle or two on each plate, the rest of the surface being covered by minute and closely set granulations ranged in transverse rows. The antero-lateral ambulacra are undepressed and superficial, and exhibit a slight and graceful curve; they are composed of an inner series of minute and approximated pairs of pores, and an outer or hinder series in which the pores of each pair are widely separated and unequal (the outer ones being the longest), and connected by a shallow groove. There are about thirty pairs of pores in the petaloidal portion of each series; the petals are also plain and undepressed, but are more regularly lanceolate in shape in consequence of the two series of pairs of pores in each being of nearly similar structure and but slightly unequal in width. There are about eighteen pairs in each petaloid avenue. A few tubercles (fig. 3 *b*) are seen upon the lateral ambulacra. On the interambulacral spaces they are much more numerous though set well apart and much larger. They are largest on the anterior segments, where they have wide areolæ (fig. 3 *c*). Their interstices over the whole of the test are occupied by minute granules, which are, however, not so small or so regularly arranged as those on the odd ambulacral plates. On the under surface the tubercles are confined for the most part to the interambulacral spaces, and are especially numerous, regular, and closely set on the ovato-lanceolate post-oral space formed by the inferior portion of the hinder ambulacrum (fig. 2 *b*). This space exhibits a prominent caudal gibbosity. The tubercles are minute and perforated; they are elevated upon crenulated bosses (fig. 3 *d*). The tracks of the ambulacra are naked. The spines are unknown.

The apical disc is small, and is composed of four perforated genital plates, the perforations of which are approximated. In the midst of them is seen the madreporiform body. A fifth genital plate is imperforate; the five ocular plates are all perforated, but very minute (fig. 2 *f*).

Affinities and Differences.—It very much resembles *E. Fittoni* in its form, outline, and tumidity. It is, however, a larger Urchin, with larger tubercles on the upper surface, and having them more sparsely distributed on the plates.

Locality and Stratigraphical Position.—The specimens I have figured are in the Museum of the Royal School of Mines, and are the same which were so beautifully

drawn by Mr. C. R. Bone for my late esteemed colleague Professor Edward Forbes, whose accurate description I have adopted. They were collected from the Greensand of Blackdown in Devonshire, a formation whose geological horizon is probably about the junction of the Gault and Upper Greensand, and I am not aware the species has been found in any other locality.

Family 13.—Echinocoridæ, *Wright*, 1856.

The Urchins of this family have an oval, cordate, or conoidal test, which often attains a considerable size.

The ambulacral areas are equal, narrowly lanceolate, and converge to one ambulacral summit, which is always the vertex of the test.

The poriferous zones are narrow, and the pores are disposed in pairs at some distance apart.

The surface of the plates of both areas has in general two horizontal rows of very irregular, small, perforated tubercles, raised upon bosses with crenulated summits, and having around their bases a circle of very small granules; the entire surface of the plates in some well-preserved tests is likewise covered with a profusion of similar microscopic granulations.

The mouth-opening is always placed near the anterior border; it is transversely oblong, and often bilabiate; the vent is round, and opens either at the base, near the margin, or in a supra-marginal region of the posterior border in different genera.

The apical disc is usually narrow and much elongated; it consists of four perforated and one unperforated ovarial plate, with five perforated oculars: the whole of the elements are well soldered together, and often covered over with a thin granulated layer of the test, which conceals the sutures of the disc and converts the whole into a single mass. In the genus *Stenonia* the apical disc is short and compact; it is likewise small in *Holaster* and *Cardiaster*, and large and elongated in *Echinocorys*.

The cordate forms have an anteal sulcus feebly shown in *Holaster*, but largely developed in *Cardiaster*, whilst in the conoidal forms, as *Echinocorys* and *Stenonia*, it is absent. In the genus *Cardiaster* there is a marginal fasciole, which passes under the periprocte.

The Echinocoridæ are an extinct family of the cretaceous period, and the species are distributed throughout all the rocks of this formation from the Neocomian strata up to the beds of uppermost White Chalk. One living form which connects this family with the Spatangidæ ought, perhaps, to be placed here, the genus *Palæopneustes*, Agassiz, a singular Urchin which was dredged near Barbadoes by the Hassler expedition.

The extinct genera are:

Echinocorys, *Breynius.*	Holaster, *Agassiz.*
Stenonia, *Desor.*	Cardiaster, *Forbes.*

All the extinct genera are found in British rocks with the exception of *Stenonia*, which is collected only in the White Chalk of Italy, or *Scaglia* of the Vicentin, at Monte di Magre. The living genus Paæopneustes, *Agassiz*, has at present an "incertum sedis" in this group.

Genus—Cardiaster, *Forbes*, 1850.

Spatangus, *Auctorum.*
Holaster (pars), *Agassiz.*
Infulaster, *Borchards.*

Test cordate, tumid, or depressed; lateral ambulacra having the upper part of their avenues slightly dissimilar; all the ambulacra convergent on the vertex, the anterior single ambulacrum lodged in a strongly marked anteal sulcus with angulated borders. A fasciole passing beneath the vent and continued on the sides. Apical disc elongated, and composed of four perforated genital and five perforated ocular plates. Tubercles perforated, raised upon crenulated bosses, and surrounded by areolæ.

Cardiaster possesses all the characters of Holaster, from which it is distinguished by the presence of a subanal fasciole, and a deeper anteal sulcus with more angulated sides.

Cardiaster Benstedi, *Forbes*, 1852. Pl. LXVI, figs. 3 *a, b, c*; Pl. LXXI, figs. 4 and 5.

Cardiaster Benstedi, *Forbes.* Mem. of Geol. Survey, decade iv, pl. ix, notes, 1852.
— — *Morris.* Catalogue Brit. Foss., 2nd edit., p. 73, 1854.

Diagnosis.—Test cordiform, broad, hemispherical, upper surface convex, rotund, anteal sulcus shallow, lateral ambulacra narrow, poriferous zones narrow and unequal.

Dimensions.—Length one inch and a half; breadth one inch and a half; height one inch.

Description.—The anteal sulcus is strongly marked and wide below. The upper surface is gently curved, convex, and rotund. The poriferous zones are all remarkably narrow, and the posterior as broad as the antero-laterals. Pl. LXVI, fig. 3 *a*, represents the upper convex surface, showing the very narrow zones with the central apical disc and its four

perforated ovarial plates. Fig. 3 *b* gives a lateral view, showing the increased elevation at the anterior third, and fig. 3 *c* shows the position of the vent with its oval periprocte in the posterior border. Pl. LXXI, figs. 4 and 5 are figures of this Urchin from the Lower Greensand of the Isle of Wight. This species was first described by Professor Edward Forbes in the 'Memoirs of the Geological Survey,' decade iv, in his notes on British species of Cardiasters appended to his description of pl. ix. It was collected from the Lower Greensand of Maidstone, and presented to the Royal School of Mines Museum by Messrs. E. H. Bunbury and Professor Morris. The specimens were too imperfectly preserved to be described. The one that forms the subject of our figure in Pl. LXVI belongs to the collection of the British Museum, and I understand it was collected from the same rock and locality.

The test is broad, cordate, and hemispherical, convex on the upper surface, and inflated at the sides. The anteal sulcus is wide below and shallow in the upper part; the ambulacrum smooth in the middle, with a row of tubercles on each side of the angles; the pores are minute, remotely placed in oblique pairs; the antero-lateral ambulacra are narrowly lanceolate; the poriferous zones contracted, and the pores are like fine slits set wide apart; the postero-lateral pair are about the same width but shorter than the anterior pair. The surface of all the plates is covered with a minute, close-set granulation, and at the anterior border a few irregular rows of larger tubercles are developed. The back is gently curved towards the upper angle of the vent, which occupies the middle of the posterior border (Pl. LXVI, fig. 3 *b*, *c*, and Pl. LXXI, fig. 4 *d*).

The base is much distorted in most of the specimens, appears to have been flat and had numerous rows of large tubercles set upon the central plastron, and the sides and anterior portion.

The mouth-opening is situated near the anterior border; it is transversely oblong and bilabiate (Pl. LXXI, fig. 4 *b*), the peristome is, unfortunately, displaced in the specimens that have come into my hands.

The apical disc is small, consisting of four pairs of perforated ovarials and five perforated ocular places (Pl. LXXI, fig. 4 *a*; Pl. LXVI, fig. 3 *a*).

The posterior border is small, narrow, and truncated (Pl. LXXI, fig. 4 *d*; Pl. LXVI, fig. 3 *c*), and the vent opens in its upper portion.

Affinities and differences.—This species, originally proposed by Professor Edward Forbes for an Urchin from the Lower Greesand of Maidstone, which he considered to be distinct from any other species, is characterised by the following diagnosis:—"*C. late cordatus, subhemisphæricus, dorso rotundato, seriebus pororum omnibus angustis subequalibus.* The anterior sulcus is strongly marked and wide below. The back is gently curved. The vent is medial in position as compared with its height. The poriferous avenues are all remarkably narrow, and the hinder ones as broad as the antero-laterals. The surface of the test is too imperfectly preserved to be described." Since the date of this description several specimens have been found in the Lower Greensand at Atherfield,

Isle of Wight, in nodules from the Walpen and Ladder Sands and Clays, with *Gryphæa sinuata* and *Ammonites* (*Hoplites*) *Martini*, d'Orbigny, and in the bed with *Gryphæa* at Shanklin Point, where several other Urchins, as *Clypeopygus Fittoni*, Wright and *Echinospatagus Renevieri*, Wright, have been found. The affinities of this species are certainly with *Cardiaster fossarius*, the smaller forms of which it closely resembles in many points of structure. The narrowness of the poriferous zones, common to both forms, cannot afford a specific character; therefore, until better examples are found for comparison, I must regard the distinction between *C. Benstedi* and *C. fossarius* as doubtful.

Locality and Stratigraphical Position.—In the Lower Greensand of Maidstone, and in the Lower Greensand at Shanklin and Atherfield, Isle of Wight.

CARDIASTER LATISSIMUS, *Agassiz*, 1840. Pl. LXVII, figs. 1, 2 *a—h*.

HOLASTER LATISSIMUS,		*Agassiz.* Catalogus Syst., p. 2, 1840.
—	—	*Agassiz et Desor.* Cat. Raisonné, p. 133, 1847.
—	—	*d'Orbigny.* Prodrome, t. ii, p. 177, 1847.
—	—	*d'Orbigny.* Paléont. Française, Ter. Crét., tom. vi, p. 92, pl. 837 and 838, 1853.
CARDIASTER SUBORBICULARIS,		*Forbes.* Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
—	—	*Morris.* Catal. Brit. Foss., p. 73, 1854.

Diagnosis.—Test cordiform, broader than long, much depressed; anterior border very wide, deeply grooved by the anteal sulcus, sides expanded; posterior half contracted and becoming rapidly narrow behind, upper surface slightly convex; anterior half more rotund and elevated than the posterior half, which developes a ridge between the disc and the posterior border, this region is narrow, elevated, and obliquely truncated, having the vent high up near the dorsal surface. Ambulacral pores narrow, poriferous slightly unequal. Anteal sulcus deep, ambulacrum with very minute round pores. Base slightly convex, depressed near the mouth, convex and elevated in the middle and posterior region over the plastron.

Dimensions.—Large specimen, fig. 1. Antero-posterior diameter two inches and $\frac{7}{10}$ths; transverse diameter two inches and $\frac{8}{10}$ths; height $\frac{11}{10}$ths of an inch.

Small specimen, fig. 2. Antero-posterior diameter two inches and $\frac{2}{10}$ths; transverse diameter two inches and $\frac{3}{10}$ths; height anteriorly $\frac{8}{10}$ths of an inch, posteriorly $\frac{9}{10}$ths of an inch.

Description.—This beautiful Cardiaster is entered in our catalogues of British Urchins as *C. suborbicularis*. It appears, however, to be identical with *Holaster*

latissimus, Agassiz, so well figured in the 'Paléontologie Française.' A careful comparison of the two fine specimens before me, which formed the subjects of our plate, with three specimens of *C. orbicularis* from the Étage Cénomanien de Cap-le-Hêve, shows that *Cardiaster latissimus* is more depressed and proportionately wider to its length than the specimens of *C. suborbicularis* from Havre measured by me. Moreover, in the latter the under surface is more convex, and the plastron ridged, and the posterior border more elevated than in our English specimen. I have lately had the advantage of examining at Auxerre my friend Monsieur G. Cotteau's magnificent collection of recent and fossil Echinodermata, and of comparing *Cardiaster orbicularis* and *C. latissimus* with each other, and find that his type-specimens of the latter species are identical with the Echinide I have figured under that name from the Upper Greensand of Dorsetshire.

The body is cordiform and much depressed, it is rounded before, and deeply grooved by the anteal sulcus, the sides are widely expanded, and the posterior border is contracted and acuminated. The upper surface is convex and a little more elevated at the anterior than at the posterior third; a ridge rising along the middle line from the disc backwards gives a marked character to the smaller specimen (figs. 2 *b* and *c*). The pairs of ambulacra are unequal. The anterior pair are slightly curved outwards and forwards, and the posterior are shorter and directed straight outwards and backwards (figs. 1, 2 *b*). The poriferous zones are narrow, and composed of small equal-sized holes (fig. 2 *e*). The anterior single area is lodged in a deep sulcus, the zones are feebly developed, and the holes very minute (fig. 2 *f*). The surface of the plates, especially those about the anterior border and the base, has a number of small tubercles developed on their surface (figs. 2 *a* and 2 *e*). The tubercles are mammillated, with crenulated bosses and perforated summits (fig. 2 *g*). The apical disc is small and elongated, with four perforated ovarial plates (fig. 2 *h*) and five small oculars.

The under surface (fig. 2 *a*) is flattened, a little convex in the region of the plastron, and concave at the sides and around the anterior border. The mouth-opening is placed in a depression near the junction of the anterior fourth with the middle fourths of the base. The peristome is small and bilabiate (fig. 2 *a*). The arrangement of the tubercles on the base is very well shown in this drawing, which gives a more correct notion of their comparative size and distribution than any description can convey.

The vent is situated high up in the posterior border (fig. 2 *c*), which is narrow and truncated obliquely downwards and inwards (fig. 2 *b*), with a beak-like process overhanging the upper angle of the vent, the periprocte of which has an oval form (fig. 2 *c*).

Affinities and Differences.—I have already pointed out the affinities and differences subsisting between this species and *C. suborbicularis;* there is no other congeneric form in our Upper Greensand strata with which it can be confused; it is altogether a very rare form in our area.

Locality and Stratigraphical Position.—The large specimen was obtained from the

Upper Greensand of Golden Cap, near Bridport, on the Dorsetshire coast, and the small specimen from the Cowstones, Upper Greensand, at Black Ven, near Lyme Regis, Dorset, and all the other British specimens on record were collected from the same beds on the Dorset coast. It appears, however, to be a very rare form in that county.

In France it is found in the Cénomanien at Havre, and at Grand-Prè, Meuse, and Ardennes, in the same étage.

The specimen in the Royal School of Mines, Jermyn Street, is from the Upper Greensand of the neighbourhood of Osmington, in Dorsetshire, where it was obtained by Mr. E. H. Bunbury, who presented it to the Museum of that Institution.

CARDIASTER FOSSARIUS, *Benett*, 1831. Pl. LXVIII, figs. 1 *a*—*e*.

SPATANGUS FOSSARIUS,	*Benett.*	Catalogue of Upper Greensand Fossils, p. 7, 1831.
HOLASTER GREENOUGHII,	*Agassiz and Desor.*	Cat. Raisonée, p. 133, 1847.
MICRASTER FOSSARIUS,	*Morris.*	Catalogue of Brit. Foss., p. 54, 1843.
CARDIASTER —	*Forbes.*	Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
— —	*Forbes.*	Morris's Catalogue, 2 ed., p. 73, 1854.
— —	*D'Orbigny.*	Paléontologie Française, Ter. Crétacé, tome vi, p. 124, pl. 820, 1855.

Diagnosis.—Test large, cordiform; length and width nearly equal, greatest diameter at the anterior third; deeply grooved at the anterior border, with prominent marginal carinæ, much elevated anteriorly and contracted posteriorly; the highest point of the test behind the ambulacral summit; posterior border truncated; base slightly convex, with an elevated ridge on the plastron, periprocte in the upper part of the border having a blunt carina extending from its upper part to the disc; test covered with very small tubercles.

Dimensions.—Antero-posterior diameter, $2\frac{6}{10}$ inch; transverse diameter, $2\frac{6}{10}$ inch; height, $1\frac{7}{10}$ inch. This is the size of the large figured specimen. Smaller tests which I have measured bear the same relation in their several diameters to each other as that given for the type.

Description.—This is the fine Wiltshire *Cardiaster* long ago mentioned in Miss Benett's 'Catalogue of Wiltshire Fossils' as *Spatangus fossarius*. A specimen of this species was sent by Mr. Greenough to the Paris Museum, which was entered in Agassiz and Desor's 'Catalogue Raisonné' as *Holaster Greenoughii*. It has been long a leading fossil Urchin in the Upper Greensand of Wilts, and appears to be special to that English formation, as I have not found any specimen approaching this form from the Cenomanian

Stage on the Continent. The test is largely cordiform, having the length and breadth of nearly equal diameters; the anterior border is convex, with a deep anteal sulcus, having sharply defined carinal borders extending upwards towards the apical disc; the summit of the ridges forming the sides of this sulcus attain the highest point in the test. The posterior half of the shell tapers considerably towards the posterior border, which is narrow, truncated, and depressed. The sides and border are slightly angular from the way the broad plates forming the interambulacra areas are bent, and this angularity imparts a very marked character to the tests of this Urchin. Figs. 1 *a* and *c* show these angles fairly well.

The ambulacral areas are of unequal width; the anterior pair are the longest and largest, and extend across the test; their poriferous zones are unequal, as the inner series have the pores more nearly approximated than those of the outer series; the apertures have the form of narrow slits, and the pairs of pores are placed close together in the upper part of the zones, but become wider asunder as the discal distance increases, so that at the middle of the side they are much wider apart, and on the lower part of the ambitus quite remote from each other (figs. 1 *a*, *c*).

The posterior pair of ambulacra are much shorter and directed backwards; the pores in their zones are likewise in the form of slits, and become in like manner wider asunder as they descend the area. The ambulacra and poriferous zones are in no way depressed, and occupy the surface of the test (figs. 1 *c*, *d*).

The inter-ambulacral areas are very wide, and built up of long plates, which are bent transversely near their middle; this bending of the plates produces the angles in the test already referred to; between the antero- and postero-lateral ambulacra the angles are marked out by a series of knotty lines along the sides of the test, and a similar ridge runs between the antero-lateral ambulacra and the prominent sides of the anteal sulcus, so that the angularity of the test is an interesting character of this species.

The upper surface is covered with very minute tubercles, which become a little larger on the anterior border and are still larger on the sides of the anteal sulcus.

The apical disc is small, and well soldered into the plates of the test; there are four perforated ovarials, and five ocular plates.

The under surface is convex and angular; the plastron forms a prominent ridge, which divides the posterior half along the mesial line, and it becomes concave at the anterior third where the mouth is situated (fig. 1 *b*); the basal plates are covered with larger tubercles, which have a well-defined arrangement on the plastron and on the lateral parts of the base (fig. 1 *b*).

The mouth-opening is near the anterior border; it is a wide opening, transversely oblong, with a well-defined peristome and rudimentary labial process.

The vent is oval, and situated in the upper part of the posterior border, which is depressed (fig. 1 *d*); two ridges extend vertically along the sides of the border, and increase the depth of the concavity in which the periprocte is placed, producing a beak-

shaped projection at the superior part of the border where the two carinæ meet above the vent as seen in profile in fig. 1 *e*.

Affinities and Differences.—This species is well characterised by its large, deep, anteal sulcus, angular upon the sides, where it is sharply defined by its two carinæ, and prolonged from the peristome below to the apical disc above by these boundary ridges arising from the folds of the test. These characters added to the height of the test with its angular circumference easily distinguish it from *Cardiaster latissimus*, and the same group of characters readily mark it out as a very distinct form from *Cardiaster granulosus* and *C. bisulcatus*.

Locality and Stratigraphical Position.—This species has been collected only from the Upper Greensand of Wiltshire; it was formerly an abundant fossil in these beds; but has, however, now become scarce; fine specimens with the test in good preservation are seldom found. The large shells I have figured belonged to Mr. Cannington's collection, and were collected many years ago. These grand specimens now belong to the British Museum.

CARDIASTER PEREZII, *Sismonda*, 1843. Pl. LXVIII, fig. 2 *a*, *b*, *c*.

HOLASTER PEREZII,	*Sismonda.*	Sugli Ech. Foss. di Nizza, p. 11, pl. i, figs. 1—3, 1843.
—	—	*Agassiz and Desor.* Catalogue Raisonné des Échinides, p. 135, 1847.
—	—	*Albin Gras.* Oursins Fossiles de l'Isére, p. 62, 1848.
—	BISULCATUS,	*Albin Gras.* Oursins Fossiles de l'Isére, p. 62, pl. iv, figs. 7, 8, 1848.
—	PEREZII,	*d'Orbigny.* Prodrome, t. ii, p. 141, 1850.
—	—	*d'Orbigny.* Paleont. Française Ter. Cret., p. 86, pl. dcccxiii, figs. 1—7, 1853.
CARDIASTER BISULCATUS,	*Forbes.*	Mem. Geol. Surv., decade iv, pl. ix, Notes on Cardiasters, 1852.
—	—	*Morris.* Catalogue of British Fossils, 2nd ed., p. 73, 1854.
HOLASTER PEREZII,	*De Loriol.*	Echinid. Helvétique Ter. Cret., p. 325, pl. xxvii, figs. 6—8. 1873.

Diagnosis.—Test convex, enlarged before, contracted behind, elevated anteriorly to the ambulacral summit, and gradually inclined from thence to the posterior border, anteal sulcus short, deeply indenting the anterior border, antero-lateral ambulacral narrowly lanceolate; postero-lateral ambulacra short and wide; posterior border accuminated and oblique, vent low down in a small truncated area, periprocte oval. Primary tubercles very small in proportion to the size of the test, a dorsal carina extending from the vertex to the border; apical disc small, situate at the junction of the anterior, with the middle third of the upper surface.

Dimensions.—Antero-posterior diameter two inches and one tenth ; transverse diameter two inches ; height one inch and one tenth.

Description.—In notes to a list of British Cardiasters appended to a description of pl. ix, decade iv, of the 'Memoirs of the Geological Survey of the United Kingdom,' Professor Edward Forbes says, "in the Museum of Practical Geology there is a *Cardiaster* from the Greensand of Blackdown, remarkable for the small tubercles in proportion to its size and the great width of the hinder lateral poriferous avenues. It seems to be identical with the *Holaster bisulcatus*, described and figured by M. Albin Gras in his 'Oursins fossiles de l'Isére.'" I had a very careful drawing of this rare Urchin made from the type specimen, and placed it (fig. 2 *a*, *b*, *c*) on the same plate with *C. fossarius*, to show its near affinity with that form.

The test is cordate, about as long as it is wide; the anterior border is elevated (fig. 2 *b*) and deeply indented (fig. 2 *a*) by the anteal sulcus, which is well defined by the angular folds bounding the depression on both sides (fig. 2 *c*) ; the central portion of the ambulacrum is smooth and the pairs of pores minute and distinct from each other. The antero-lateral ambulacral pairs (fig. 2 *a*) are short, narrowly lanceolate, and the postero-lateral pair wider behind ; the poriferous zones of all the avenues are narrow, and their pores are small slit-like apertures. The ambulacral summit is near the anterior border of the junction of the anterior with the middle third of the test. The apical disc which occupies this point is small, compact, and formed of four perforated ovarial and five minute ocular plates. The surface of the plates carry very small tubercles in proportion to the size of the test, a well-marked character originally pointed out by Forbes. A few larger tubercles occupy the angles of the sulcus and anterior border, but on the other portions of the upper surface they are very uniformly diminutive. The posterior border much accuminated above (fig. 2 *a*) and obliquely truncated inwards below (fig. 2 *b*) ; the anal area is very limited, and the oval periprocte opens at the top of the oblique truncature of the posterior border.

Affinities and differences.—*Cardiaster Perezii* resembles *C. fossarius* in many of its essential characters ; it differs, however, in some minor points in the anatomy of its test ; the posterior half is much more accuminated, the anal area much smaller, the upper surface is likewise more inclined from the vertex of the border than in *C. fossarius*. The tubercles are smaller on the upper surface, but larger, and more developed at the base. The continental authorities as MM. d'Orbigny, Cotteau, and De Loriol, consider this Urchin as a true *Holaster*. In deference to the opinion of my lamented colleague Professor Edward Forbes I have left it in the genus in which he placed it.

Locality and Stratigraphical Position.—This Urchin is very rare in England, and has been collected only from the Upper Greensand at Blackdown with *Echinospatagus Murchisonianus*. In France it is found in the Gault at Ravis (Isere), and at Clar near Escragnolle. In Switzerland, Perte-du-Rhône, Sainte-Croix (Vaud), Wannealp, Oberalp (Wæggithal), Cheville, Bossetan (Valais), and in France, near Nice.

PLATE LXII A.

Micraster cor-bovis, *Forbes.*

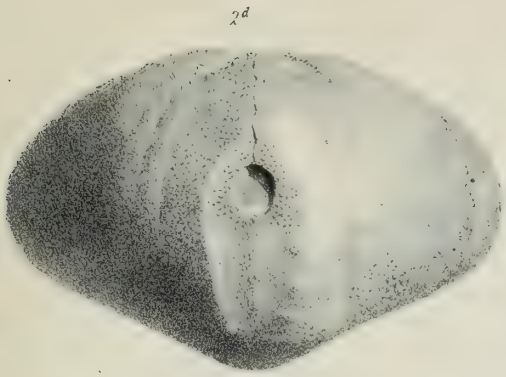
From the Upper White Chalk.

Fig. 1. Base of large test, natural size. British Museum. (P. 276.)
2 *a*. Upper surface do.
b. Lateral view do. do.
c. Anterior border, anteal sulcus, and mouth opening.
d. Posterior border, with vent and periprocte.

Micraster breviporus, *Agassiz.*

From the Upper White Chalk.

Fig. 3 *a*. Upper surface, natural size. My collection. (P. 278.)
b. Under do. do.



2d

2c

3b

2b

3a

2a

1

C. R. Bone del. et lith.

Vincent Brooks Day & Son Imp.

PLATE LXIII.

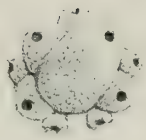
EPIASTER GIBBUS, *Lamarck.*

From the Upper White Chalk.

Fig. 1 *a*. Upper surface, natural size. My collection. (P. 267.)
b. Under do. do.
c. Lateral do. do.
d. Posterior do. do.
e. Anterior do. do.
f. Apical disc, magnified four diameters.
g. Ambulacral and inter-ambulacral plates, magnified three times.
h. Structure of the poriferous zones, magnified.
i. Primary tubercles on upper surface do.
k. Do. do. from basal do. do.

1b

1f



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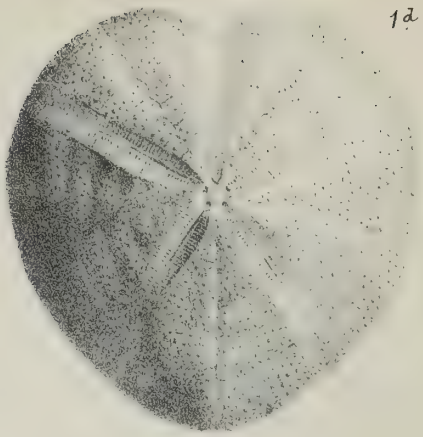

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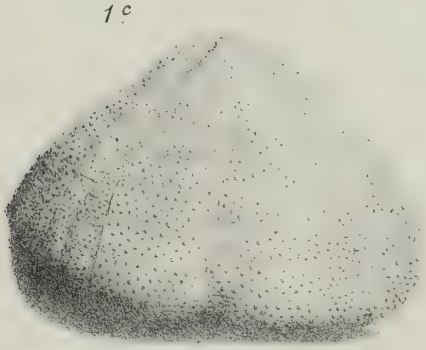
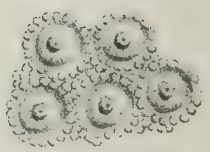


1k

1i



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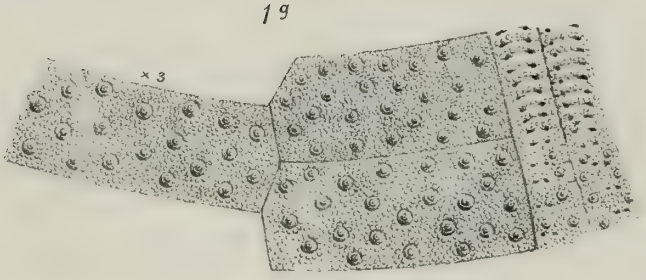

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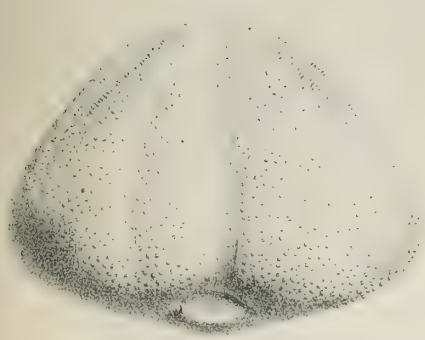
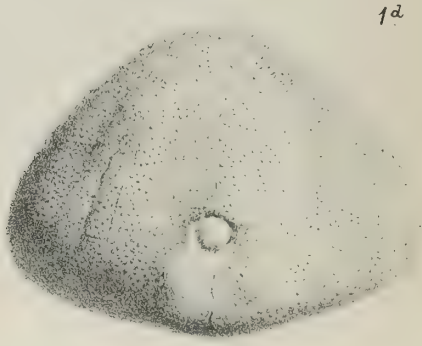


1h

1d



C.R. Bone del. et lith.

W. West & Co. imp.

PLATE LXIV.

Echinospatagus Murchisonianus, *Mantell.*

From the Upper Greensand.

Fig. 1. Test, upper surface, natural size. My collection. (P. 281.)

Enallaster Greenovii, *Forbes.*

From the Upper Greensand.

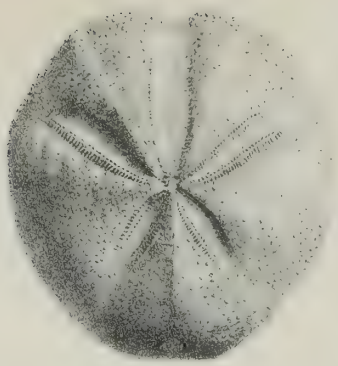
Fig. 2 *a*. Upper surface, natural size. Royal School of Mines. (P. 290.)
b. Under do. do.
c. Posterior do. do.
d. Anterior do. do.
e. Lateral do. do.
f. Apical disc and structure of ambulacra, magnified.
3 *a*. Smaller test, lateral view.
b. Plates, with tubercles from upper surface, magnified.
c. Tubercles from under surface, do. do.
d. Do. do.

Echinospatagus Collegnii, *Sismonda.*

From the Upper Greensand.

Fig. 4. Test, upper surface, natural size. My Collection. (P. 283.)

1



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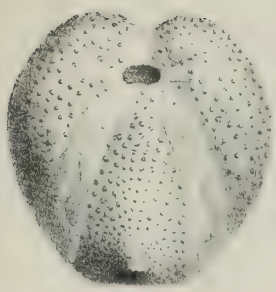

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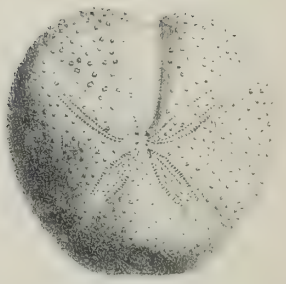

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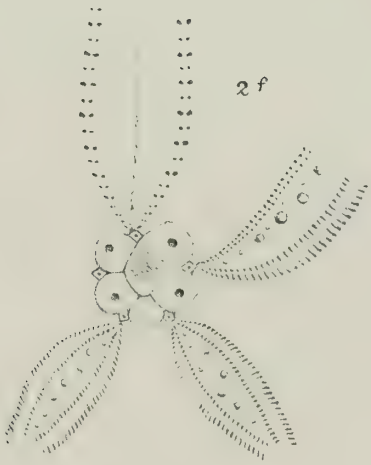

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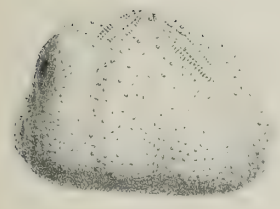
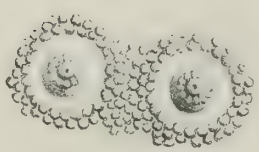


3 a

3 c



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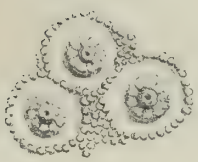

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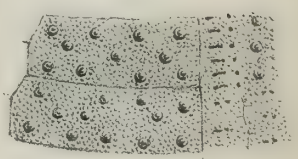
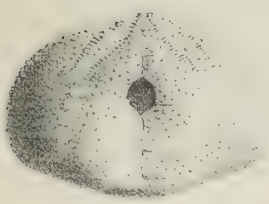


4

2 c



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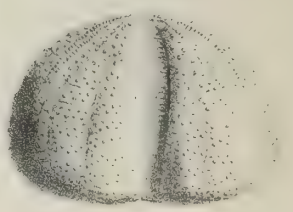

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PLATE LXV.

Enallaster Fittoni, *Forbes.*

From the Lower Greensand.

Fig. 1 *a*. Upper surface, natural size. Royal School of Mines. (P. 288.)
b. Under do. do.
c. Lateral do. do.
e. Anterior do. do.
f. Portion of dorsal plates and tubercles, magnified three times.
Fig. 2 *a*. Upper surface of test, natural size. My collection.
b. Apical disc and single ambulacrum, magnified.
c. Anterior petaloid ambulacrum, showing poriferous zones.

Holectypus bistriatus, *Wright.*

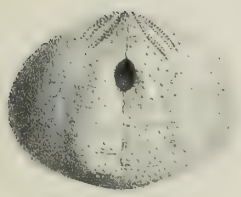
From Chloritic Marl of Chard.

Fig. 3 *a*. Test, upper surface, natural size. My collection. (P. 233.)
b. Lateral view, do.
c. Structure of an ambulacrum, showing the bistriated marginal arrangement.

1a

2b

1b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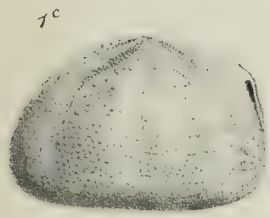
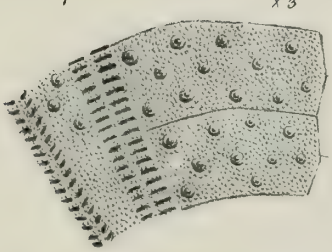
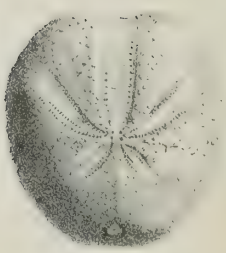
1e

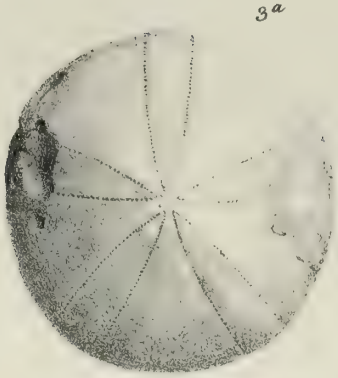

1c

1f x3




2a

3b


3a

x2

3c

C.R. Bone del et lith.

W. West & Co imp.

PLATE LXVI.

GONIOPYGUS DELPHINENSIS, *Albin Gras.*

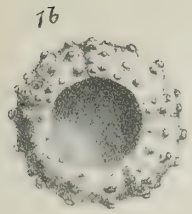
From the Farringdon Sponge Bed, Lower Greensand.

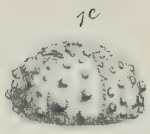
Fig. 1 *a*. Upper surface, natural size. My cabinet.
b. Under do. do.
c. Lateral do. do.
d. Interambulacrum, magnified four times.
e. Ambulacrum, do. do.
f. Apical disc, do. three times.
g. Ambulacral plates, do. six times.

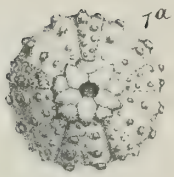
CARDIASTER BENSTEDI, *Forbes.*

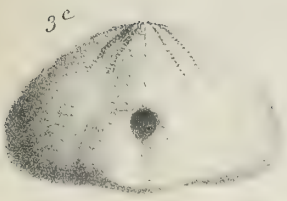
From the Lower Greensand.

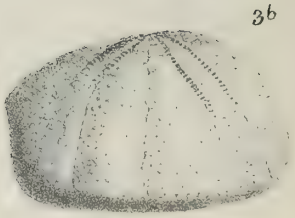
Fig. 3 *a*. Upper surface, natural size. British Museum. (P. 293.)
b. Lateral view, do.
c. Posterior view, do.











C.R.Bone del et lith.

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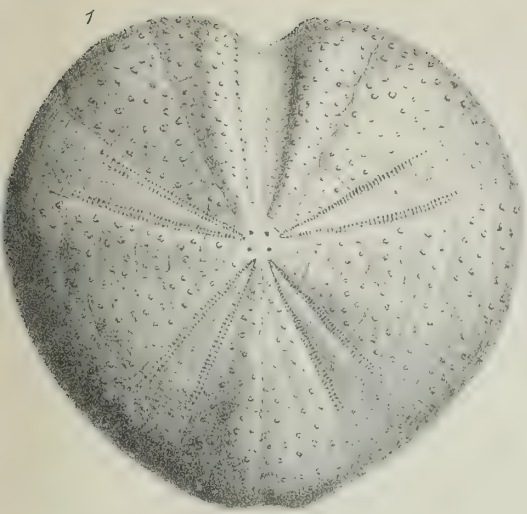
PLATE LXVII.

Cardiaster latissimus, *Agassiz.*

From the Upper Greensand.

Fig. 1. Upper surface, natural size. My Cabinet. (P. 295.)
2 *a*. Under surface, natural size. Rev. T. Wiltshire's, F.G.S., Collection.
b. Lateral view do.
c. Posterior border do. with periprocte and vent.
d. Anterior do. do. with anteal sulcus.
e. Dorsal plates and primary tubercles with granules, magnified three times.
f. Ambulacral pores, magnified three times.
g. Primary tubercles from the base. Magnified.
h. Apical disc, magnified.

1



2a

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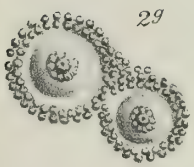
2f

2g



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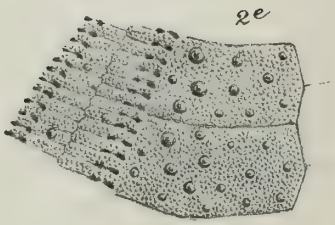

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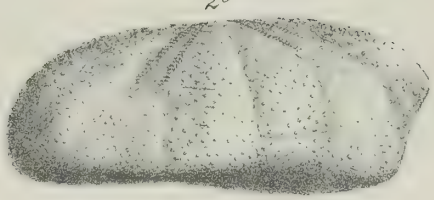

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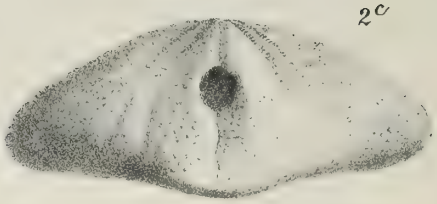

C.R.Bone delet hth.

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PLATE LXVIII.

Cardiaster fossarius, *Benett.*

From the Upper Greensand.

Fig. 1 *a*. Upper surface, natural size. Cunnington collection. British Museum. (P. 297.)
b. Under surface do.
c. Lateral view do.
d. Posterior do. do.
e. Anterior border, do.

Cardiaster Perezii, *Sismonda.*

From the Upper Greensand.

Fig. 2 *a*. Upper surface, natural size. Jermyn Street Museum. (P. 299.)
b. Lateral view do.
c. Anterior border do. with anteal sulcus.

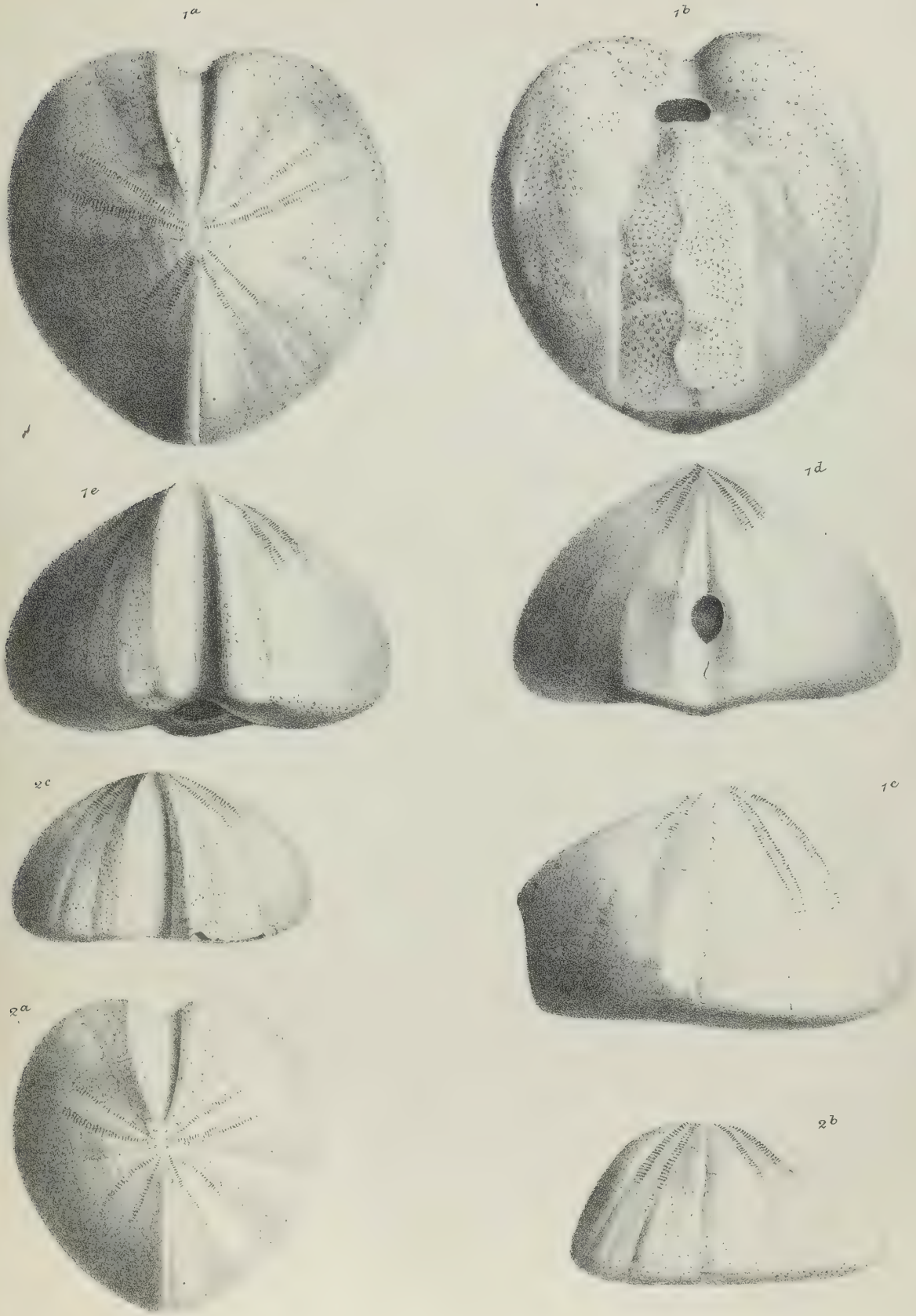

1a
1b
1d
1e
2c
1c
2a
2b

PLATE LXIX.

Cardiaster pygmæus, *Forbes.*

From the Upper Chalk.

Fig. 1 *a.* Upper surface, magnified twice. Museum Royal School of Mines. (P. 301.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte, magnified twice.
e. Anterior border and anteal sulcus do.

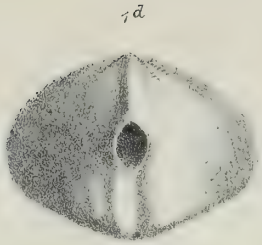
Cardiaster granulosus, *Goldfuss.*

From the Upper Chalk.

Fig. 2 *a.* Upper surface, natural size. My Collection. (P. 302.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Plates with tubercles from upper surface, magnified.
g. Marginal plates with tubercles and marginal fasciole.
h. Tubercles from the dorsum, highly magnified.
i. Do. do. base do.

Fig. 3. Flint mould of *Cardiaster granulosus.*

1a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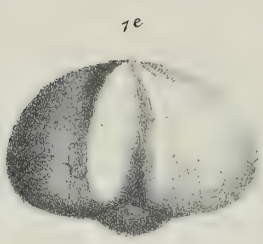
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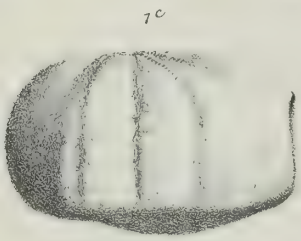
1b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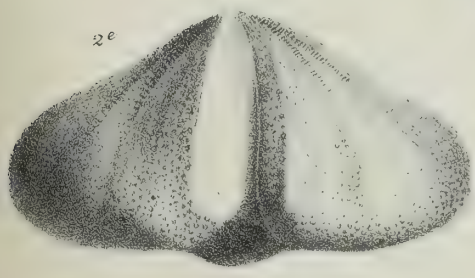
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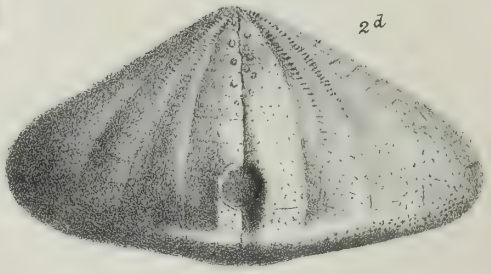
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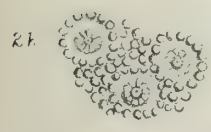
2g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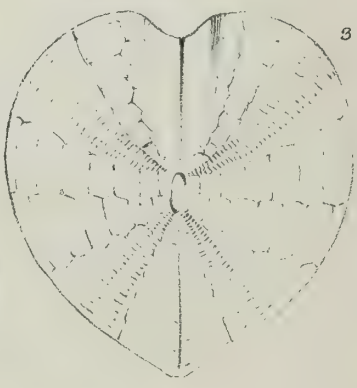
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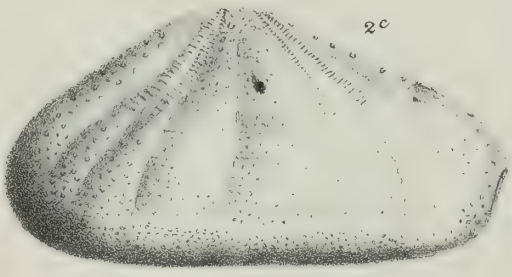
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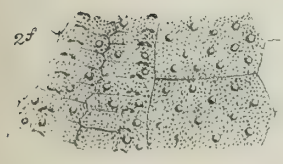
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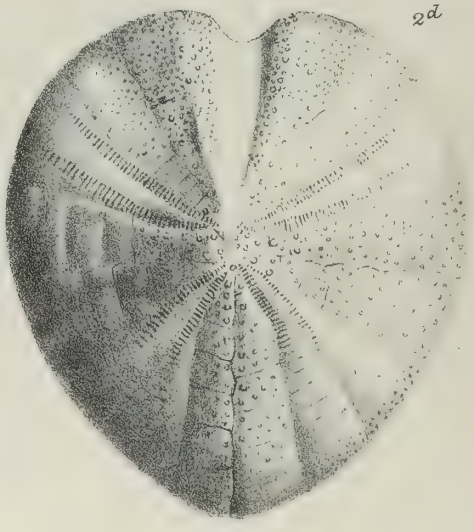
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THE

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INSTITUTED MDCCCXLVII.

LONDON:

MDCCCLXXVIII.

THE OOLITIC ECHINOIDEA.

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The Monograph on the Oolitic Echinoidea will be found in the volumes of the Palæontographical Society for the years 1855, 1856, 1857, 1858, and 1878.

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ORDER OF BINDING AND DATES OF PUBLICATION.

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1—154	I—X	1855	February, 1857
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303—390	XXIII—XXXVI	1857	November, 1859
391—468	XXXVII—XLIII	1858	March, 1861
469—481	—	1878	March, 1878

MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

OF

THE OOLITIC FORMATIONS.

BY

THOMAS WRIGHT, M.D., F.R.S. EDIN., F.G.S.,

VICE-PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY; CORRESPONDING MEMBER OF THE ROYAL SOCIETY OF SCIENCES OF LIÉGE; THE SOCIETY OF NATURAL SCIENCES OF NEUCHÂTEL; VICE-PRESIDENT OF THE COTTESWOLD NATURALISTS' FIELD CLUB; CONSULTING SURGEON TO THE CHELTENHAM HOSPITAL; AND MEDICAL OFFICER OF HEALTH TO THE URBAN SANITARY DISTRICTS OF CHELTENHAM, CHARLTON KINGS, AND LECKHAMPTON.

VOLUME I.—THE ECHINOIDEA.

LONDON:

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1857—1878.

PRINTED BY
J. E. ADLARD, BARTHOLOMEW CLOSE.

INTRODUCTION.

I DELAYED the Index to my Monograph on the Oolitic Echinoidea in the hope that after the publication of the Fourth Part some new species from time to time would be discovered in our Jurassic rocks, and thereby have necessitated a Supplement to the work. Up to the present time I have waited for new forms in vain; and, as numerous inquiries have been made for the index, my most kind and considerate friend, our worthy Secretary, knowing how much my time is occupied with important public duties, kindly offered to prepare the same, and the members of the Palæontographical Society owe to the Rev. Thomas Wiltshire, M.A., Sec. G.S., their thanks for the full and well-classified Index which accompanies this sheet.

In taking a retrospective glance at the progress of the Monograph it is very satisfactory to find that so little remains to be added to the Oolitic species of Echinoidea described and figured therein; and indeed, as far as I am aware, nothing requires to be retracted from any of its pages. It has been my constant endeavour throughout the many years I have been engaged in its composition to do ample justice to all naturalists who, either as contemporaries or as predecessors, have been engaged in the study of the interesting groups of fossil forms included in the class Echinodermata.

Since I commenced this Oolitic Monograph several very important works have enriched this branch of Palæontology. In France my learned friend M. Gustave Cotteau has published 'Études sur les Échinides fossiles du Département de l'Yonne.' The first volume contains figures and descriptions of all the species in the Terrain Jurassique, and the second volume is dedicated to the Cretaceous species, which I shall notice in due course in my Memoir on the Echinoids from

the Cretaceous Formations now nearly completed. Associated with the late M. Triger, M. G. Cotteau has published with admirable plates his 'Échinides du Département de la Sarthe,' a work which includes both Jurassic and Cretaceous species. M. G. Cotteau has also published a series of papers in the 'Revue et Magasin de Zoologie' on "Échinides nouveaux ou peu connus," containing many rare forms of Jurassic species, and several other important memoirs on Echinoderms from other formations.

In Switzerland my learned friend M. E. Desor published in 1858 his valuable 'Synopsis des Échinides fossiles,' illustrated with an atlas of well-executed plates (this work being a revised and enlarged edition of the 'Catalogue raisonné des Échinides' by Agassiz and Desor); and, in conjunction with my learned friend M. P. De Loriol, he issued the large work entitled 'Échinologie Helvétique,' containing accurate descriptions and excellent figures of all the species of Echinoidea found in the Jurassic rocks of the Alps.

M. P. De Loriol has followed up this important national work with a second volume, comprising the "Échinides" of the Cretaceous period, to which I shall refer in detail on a future occasion.

In Germany Professor Quenstedt, of Tübingen, has published figures and descriptions of all the species of Echinoderms from the Jurassic rocks of his country, some of which previously had been so beautifully figured in the 'Petrefacta Germaniæ' of Goldfuss.

The Echinology of different Jurassic regions of Germany has had able exponents. Thus, Dr. Gustav C. Laube has contributed a memoir on 'Die Echinodermen des Braunen Jura von Balin" with beautiful plates; Dr. W. Dames has given "Die Echiniden der nordwestdeutschen Jurabildungen' with plates. The latter is an important contribution to the Palæontology of this region, as showing how closely allied the north-western Oolites of Germany are with those of England.

M. De Loriol has enriched the 'Description Géologique et Paléontologique des Étages Jurassiques supérieurs de la Haute-Marne' by MM. E. Royer and H.

Tombeck, with descriptions and figures of all the "Échinides" found in the upper stages of this Department; and my learned friend has likewise made a similar contribution to the 'Monographie Paléontologique et Géologique des Étages supérieurs de la Formation Jurassique des Environs de Boulogne-sur-Mer,' par P. De Loriol et E. Pellat; and in the 'Monographie Paléontologique and Géologique de l'Étage Portlandien du Département de l'Yonne,' par P. De Loriol et G. Cotteau, we have a combined work of much value, showing the correlation of our Portlandian series with that of France.

It is evident from this brief review that the last twenty years has been a period of great Palæontological activity throughout Europe, and it is gratifying to find that our own Society has contributed its mite to the general progress of knowledge relating to the Echinoderms of the Oolitic formations of the British Islands.

THOMAS WRIGHT, M.D., F.R.S.E.

4, St. Margaret's Terrace, Cheltenham;
16*th January*, 1878.

INDEX

TO THE

BRITISH FOSSIL ECHINODERMATA OF THE OOLITIC FORMATIONS.

VOLUME I.—THE ECHINOIDEA.

PAGE

BIBLIOGRAPHY . . . . . 437—449

NOMENCLATURE . . . . . 1—8

STRATIGRAPHICAL DISTRIBUTION :—

Horizons—

Purbeck Cinder Bed . . . . . 98—100

Portland Oolite . . . . . 96—98 ; 353—355 ; 453—454

Kimmeridge Clay . . . . . 53 ; 166—168

Coralline Oolite . 44—52 ; 92—96 ; 100—101 ; 124—135 ; 161—166 ; 186—188 ; 215—219 ; 249—252 ; 267—268 ; 282—286 ; 303 ; 318—322 ; 346—353 ; 382—385 ; 395—408 ; 451—452 ; 467—468

Cornbrash . 84—87 ; 118—122 ; 158—161 ; 173—176 ; 197—199 ; 208—210 ; 234—240 ; 246—248 ; 260—264 ; 280—282 ; 309—318 ; 332—337 ; 341—345 ; 361—366 ; 371—374 ; 392—394 ; 459—460

Forest Marble . . . 234—238 ; 240—245 ; 248 ; 371—374 ; 392—394

Bradford Clay . . 42—43 ; 88—90 ; 112—114 ; 118—120 ; 242—245 ; 392—394

Great Oolite . 55 ; 78—87 ; 90—92 ; 112—114 ; 115—119 ; 123 ; 156—158 ; 173—176 ; 197—199 ; 213—215 ; 234—240 ; 242—245 ; 248—249 ; 275—278 ; 280—282 ; 292—298 ; 332—341 ; 261—366 ; 371—374 ; 392—394 ; 459—461

Stonesfield Slate . . . . 75—77 ; 114—115 ; 332—337 ; 361—366

Inferior oolite . 32—42 ; 58 ; 71—75 ; 112—114 ; 149—156 ; 173—178 ; 191—193 ; 197—200 ; 204—213 ; 232—234 ; 238—240 ; 260—267 ; 275—280 ; 292—303 ; 309—318 ; 332—337 ; 361—371 ; 375—381 ; 392—394 ; 451—453 ; 456 ; 459—460 ; 463—464

Lias . . 26—32 ; 54—58 ; 110—112 ; 144—149 ; 230—232 ; 456—459 ; 462

Tabular view . . . . . 413—435

TERMINOLOGY :—

Ambulacral and interambulacral areas 11

Apical disc 13

Poriferous zones 12

Spines 15

Test 9

Tubercles 13

FAMILIES, GENERA, AND SPECIES.

The Synonyms are printed in Italics.

The letters F.S. following a species intimate that that form has not yet been found in the English Oolites.

PAGE

ACROSALENIA, *Agassiz* 229
„ aspera, *Agassiz* 249
„ Bouchardii, *Desor* (F.S.) 253
„ *crinifera*, Wright; *see* Acrosalenia minuta.
„ decorata, *Haime* 249
„ elegans, *Desor* (F.S.) 254
„ granulata, *Merian* (F.S.) 254
„ hemicidaroides, *Wright* 234, 248
„ Hunteri, *Wright* (F.S.) 257
„ interpunctata, *Quenstedt* (F.S.) 255
„ Kœnigii, *Desmoulins* (F.S.) 256
„ *lævis*, Agassiz; *see* Acrosalenia spinosa.
„ *Lamarckii*, Desor; *see* Acrosalenia Wiltonii.
„ Lamarckii, *Desmoulins* (F.S.) 253
„ lens, *Desor* (F.S.) 255
„ Loweana, *Wright* 240
„ Lycettii, *Wright* 232
„ minuta, *Buckman* 230
„ parva, *Wright* 462
„ pustulata, *Forbes* 242, 460
„ radians, *Agassiz* (F.S.) 255
„ radiata, *Forbes* 248
„ *radiata*, Forbes; *see* Acrosalenia spinosa.
„ *rarispina*, McCoy; *see* Hemicidaris minor.
„ spinosa, *Agassiz* 238
„ Wiltonii, *Wright* 246
„ Woodwardi, *Wright* (F.S.) 257
Arbacia Forbesii, Wright; *see* Magnotia Forbesii.
„ hieroglyphica, *Agassiz*; *see* Glypticus hieroglyphica.
„ *Jurassica*, Cotteau (F.S.); *see* Magnotia Jurassica.
„ *nodulosa*, Goldfuss; *see* Polycyphus Normannus.
ATROPYGA, *Gray* 107, 108
ASTEROIDEA, *Wright* 3, 4

BLASTOIDEA, *Fleming* 3, 5

CIDARIDÆ, *Wright* 18, 23, 107, 451
CIDARIS, *Klein* 25, 107
„ Amalthei, *Quenstedt* (F.S.) 59
„ *Bechei*, Broderip; *see* Hemipedina Bechei.
„ Blumenbachii, *Goldfuss* (F.S.) 60

PAGE

CIDARIS, Boloniensis, *Wright* (F.S.) 53, 64
„ Bouchardii, *Wright* 36
„ Bradfordensis, *Wright* 42
„ confluens, *Forbes* 42
„ *coronata*, Buckman ; *see* Cidaris Fowleri.
„ coronata, *Goldfuss* (F.S.) 62
„ *crenularis*, Lamarck ; *see* Hemicidaris Bravenderi.
„ *diadema*, Young and Bird ; *see* Pseudodiadema hemisphæricum.
„ Drogiaca, *Cotteau* (F.S.) 61
„ Edwardsii, *Wright* 26
„ *elegans*, Morris ; *see* Cidaris Bouchardii.
„ elegans, *Goldfuss* (F.S.) 62
„ florigemma, *Phillips* 44
„ Fowleri, *Wright* 32, 451
„ *gigantea*, Agassiz (F.S.) ; *see* Diplocidaris gigantea.
„ Ilminsterensis, *Wright* 31
„ intermedia ; *see* Hemicidaris intermedia.
„ Lorierii, *Wright* (F.S.) 59
„ marginata, *Goldfuss* (F.S.) 63
„ *monilipora*, Phillips ; *see* Pseudodiadema hemisphæricum.
„ *Moraldina*, Cotteau ; *see* Rabdocidaris Moraldina.
„ *papillata*, Parkinson ; *see* Hemicidaris intermedia.
„ Parandieri, *Agassiz* (F.S.) 60
„ propinqua, *Goldfuss* (F.S.) 62
„ Smithii, *Wright* 50, 451
„ spinosa, *Agassiz* 53
„ Suevica, *Desor* (F.S.) 61
„ *vagans*, Phillips ; *see* Pseudodiadema vagans.
„ Wrightii, *Desor* 39

Cidarites, Lamarck ; *see* Cidaridæ.
„ *Blumenbachii*, Goldfuss ; *see* Cidaris florigemma.
„ *elongatus*, Roemer ; *see* Cidaris florigemma.
„ *Hofmanni*, Roemer ; *see* Hemicidaris Hofmanni.
„ *mamillanum*, Roemer ; *see* Pseudodiadema mamillanum.
„ *maximus*, Goldfuss ; *see* Rabdocidaris maxima.
„ nobilis, *Goldfuss* (F.S.) 65
„ *pseudodiadema*, Lamarck ; *see* Pseudodiadema hemisphæricum.
„ *subangularis*, Goldfuss (F.S.) ; *see* Pseudodiadema subangulare.

Clypeaster Blumenbachii, Koch and Dunker ; *see* Pygurus Blumenbachii.
„ *Hausmanni*, Koch and Dunker ; *see* Pygurus Hausmanni.
„ *pentagonalis*, Phillips ; *see* Pygurus pentagonalis.

CLYPEASTERIDÆ, *Wright* 21

Clypeopygus Hugii, Agassiz ; *see* Clypeus Hugii.

CLYPEUS, *Klein* 360
„ Agassizii, *Wright* 378
„ altus, *McCoy* 366

PAGE

CLYPEUS *angustiporus*, Agassiz; *see* Clypeus Plotii.
,, Boblayi, *Michelin* (F.S.) 386
,, *clunicularis*, Llhwyd; *see* Echinobrissus clunicularis.
,, *cordatus*, Lang.; *see* Echinobrissus scutatus.
,, *Davoustianus*, Desor; *see* Clypeus altus.
,, *dimidiatus*, Phillips; *see* Echinobrissus dimidiatus.
,, *emarginatus*, Phillips; *see* Clypeus subulatus.
,, *excentricus*, McCoy; *see* Clypeus Plotii.
,, Hugii, *Agassiz* 375
,, *lobatus*, Fleming; *see* Echinobrissus clunicularis.
,, Michelini, *Wright* 369
,, Mülleri, *Wright* 371
,, *orbicularis*, Phillips; *see* Echinobrissus orbicularis.
,, *ornatus*, Buckman; *see* Pygaster semisulcatus.
,, Osterwaldi, *Desor* (F.S.) 387
,, *patella*, Lamarck; *see* Clypeus Plotii.
,, Plotii, *Klein* 361, 466
,, Rathieri, *Cotteau* (F.S.) 387
,, rimosus, *Agassiz* 381
,, rostratus, *Desor* (F.S.) 387
,, *semisulcatus*, Phillips; *see* Pygaster semisulcatus.
,, *sinuatus*, Parkinson; *see* Clypeus Plotii.
,, Solodurinus, *Agassiz* (F.S.) 386
,, subulatus, *Young* and *Bird* 382
COLLYRITES, *Deluc* 307
,, *analis*, Desmoulins; *see* Collyrites ovalis.
,, bicordata, *Leske* 318
,, carinatus, *Leske* (F.S.) 327
,, capistrata, *Goldfuss* (F.S.) 327
,, castanea, *Desor* (F.S.) 326
,, *censoriensis*, Cotteau; *see* Metaporhinus censoriensis.
,, Desoriana, *Cotteau* (F.S.) 325
,, elliptica, *Lamarck* (F.S.) 324
,, excentrica, *Goldfuss* (F.S.) 327
,, faba, *Desor* 328
,, Loryi, *A. Gras* (F.S.) 325
,, Orbigniana, *Cotteau* (F.S.) 325
,, ovalis, *Leske* 313
,, pinguis, *Desor* (F.S.) 324
,, ringens, *Agassiz* 309
,, transversa, *d'Orbigny* (F.S.) 326
,, Voltzii, *Agassiz* (F.S.) 326
COLLYRITIDÆ, *Wright* 20, 304
CRINOIDEA, *Miller* 3, 5
CYPHOSOMA, *Agassiz* 108
CYSTOIDEA, *von Buch.* 3, 5

PAGE

DIADEMA, *Gray* 106
„ æquale ; *see* Pseudodiadema homostigma.
„ *æquale*, Agassiz; *see* Pseudodiadema æquale.
„ *affine*, Agassiz ; *see* Pseudodiadema affine.
„ *Bakeriæ*, Woodward ; *see* Pseudodiadema Bakeriæ.
„ *Bechei*, Broderip ; *see* Hemipedina Bechei.
„ *complanatum*, Agassiz ; *see* Pseudodiadema complanatum.
„ *Davidsonii*, Wright ; see Pseudodiadema mamillanum.
„ *depressum ; see* Pseudodiadema depressum.
„ *hemisphæricum*, Agassiz ; *see* Pseudodiadema hemisphæricum.
„ *homostigma ; see* Pseudodiadema homostigma.
„ *inæquale*, Agassiz ; *see* Pseudediadema inæquale.
„ *Lamarckii*, Desmoulins ; *see* Pseudodiadema hemisphæricum.
„ *mamillanum*, Roemer ; *see* Pseudodiadema mamillanum.
„ *Mooreii*, Wright ; *see* Pseudodiadema Mooreii.
„ *Orbignyanum*, Cotteau ; *see* Pseudodiadema Orbignyanum.
„ pentagonum ; *see* Pseudodiadema pentagonum
„ *placenta*, Agassiz (F.S.) ; *see* Pseudodiadema placenta.
„ *pseudodiadema*, Agassiz ; *see* Pseudodiadema hemisphæricum.
„ *spinososum*, Agassiz ; *see* Pseudodiadema mamillanum.
„ *subangulare ; see* Pseudodiadema versipora.
„ superbum, *Agassiz ; see* Pseudodiadema superbum.
„ *tetragramma*, Agassiz ; *see* Pseudodiadema tetragramma.
„ *transversum*, Agassiz ; *see* Pseudodiadema hemisphæricum.
„ *vagans ; see* Pseudodiadema vagans.
„ *versipora ; see* Pseudodiadema versipora.

DIADEMADÆ, *Wright* 18, 106, 108, 455
Diademopsis Mooreii, Desor ; *see* Pseudodiadema Mooreii.
DIPLOCIDARIS, *Desor* 56
„ Desori, *Wright* 56
„ gigantea, *Agassiz* (F.S.) 67
„ Wrightii, *Desor* 58, 452
Diplopodia pentagona, McCoy ; *see* Pseudodiadema pentagonum.
„ *subangulare*, Agassiz ; *see* Pseudodiadema versipora.
Disaster Agassizii, *Wright ; see* Collyrites ovalis.
„ *analis*, Desmoulins ; *see* Collyrites ovalis.
„ anasteroides, *Leymerie* (F.S.) 323
„ *avellana*, Agassiz ; *see* Collyrites ovalis.
„ *bicordatus*, Agassiz ; *see* Collyrites ovalis.
„ ellipticus, *Lamarck ; see* Collyrites elliptica.
„ *Eudesii*, Agassiz ; *see* Collyrites ringens.
„ granulosus, *Goldfuss* (F.S.) 323
„ Moeschii, *Desor* (F.S.) 323
„ *propinquus*, Agassiz ; *see* Collyrites bicordata.
„ *ringens*, Agassiz ; *see* Collyrites ringens.
„ *Robinaldinus*, Cotteau ; *see* Collyrites ovalis.
„ symmetricus, *McCoy ; see* Collyrites ovalis.

PAGE

Disaster *Voltzii*, Agassiz; *see* Collyrites Voltzii.
Discoidea depressa, Leske; *see* Holectypus depressus.
„ *hemisphærica*, Agassiz; *see* Holectypus hemisphæricus.
„ *inflata*, Agassiz; *see* Holectypus inflatus.
„ *marginalis*, McCoy; *see* Holectypus hemisphæricus.
„ *speciosa*, Agassiz: *see* Holectypus giganteus.
„ *speciosa*, Goldfuss: *see* Holectypus speciosus.

Echinanthites orbicularis, Young and Bird; *see* Pygurus pentagonalis.
ECHINIDÆ, *Wright* 19, 183
Echinites depressus, Leske; *see* Holectypus depressus.
„ *clunicularis*, Llhwyd; *see* Echinobrissus clunicularis.
„ *clypeatus*, Llhwyd; *see* Clypeus Plotii.
„ *cordatus*, Lang.; *see* Echinobrissus scutatus.
„ *sinuatus*, Schlotheim; *see* Clypeus Plotii.
„ *subulatus*, Young and Bird; *see* Clypeus subulatus.
„ toreumaticus, *Leske*; *see* Glypticus hieroglyphicus.
ECHINOBRISSIDÆ, *Wright* 20, 330, 446
ECHINOBRISSUS, *Breynius* 331
„ amplus, *Agassiz* (F.S.) 357
„ Brodiei, *Wright* 353
„ clunicularis, *Llhwyd* 332
„ crepidula, *Desor* (F.S.) 356
„ dimidiatus, *Phillips* 350
„ *elatior*, Breynius; *see* Echinobrissus scutatus.
„ elongatus, *Agassiz* (F.S.) 356
„ Goldfussi, *Desmoulins* (F.S.) 358
gracilis, *Agassiz* (F.S.) 358
„ Griesbachii, *Wright* 340
„ *Hugii*, Agassiz; *see* Clypeus Hugii.
„ Icaunensis, *Cotteau* (F.S.) 359
„ *latiporus*, Agassiz; *see* Echinobrissus clunicularis.
„ major, *Agassiz* (F.S.) 357
„ orbicularis, *Phillips* 341
„ *planior*, Breynius; *see* Echinobrissus clunicularis.
„ planulatus, *Roemer* (F.S.) 357
„ pulvinatus, *Cotteau* (F.S.) 358
„ quadratus, *Wright* 344
„ *Sarthasensis*, d'Orbigny; *see* Echinobrissus clunicularis.
„ scutatus, *Lamarck* 346
„ *Tarquemi*, Agassiz; *see* Echinobrissus clunicularis.
„ *Thurmanni*, Desor; *see* Echinobrissus clunicularis.
„ truncatus, *Desor* (F.S.) 359
„ Woodwardii, *Wright* 337
Echinoclypeus umbrella, Lamarck; *see* Clypeus Plotii.
ECHINOCONIDÆ, *Wright* 19, 258
ECHINOCORIDÆ, *Wright* 21

PAGE

ECHINOIDEA, *Wright* 3, 4, 6, 9, 18
„ ENDOCYCLICA, *Wright* 17, 18, 416
„ EXOCYCLICA, *Wright* 17, 18, 416
ECHINOLAMPIDÆ, *Wright* 20, 389, 467
Echinolampas pentagonalis, Phillips; *see* Pygurus pentagonalis.
ECHINONIDÆ, *Wright* 20
ECHINOPSIS, *Agassiz* 108
„ *Bechei*, Broderip; *see* Hemipedina Bechei.
„ *Nattheimensis*, Quenstedt; *see* Hemipedina Nattheimense.
„ *rotata*, Forbes; *see* Pedina rotata.
„ *Smithii*, Forbes; *see* Pedina Smithii.
ECHINOTHRIX, *Peters* 108
Echinus bigranularis, Lamarck; *see* Stomechinus bigranularis.
„ *depressus*, Leske; *see* Holectypus depressus.
„ *depressus*, Leske; *see* Echinobrissus scutatus.
„ *diadema*ta, McCoy; *see* Stomechinus germinans.
„ *discoides*, Morton; *see* Clypeus Plotii.
„ *excavatus*, Goldfuss; *see* Stomechinus excavatus.
„ *Forbesii*, Wright; *see* Magnotia Forbesii.
„ *germinans*, Phillips; *see* Stomechinus germinans.
„ *granularis*, Wright; *see* Stomechinus intermedius.
„ *gyratus*, Agassiz; *see* Stomechinus gyratus.
„ *hieroglyphicus*, Goldfuss; *see* Glypticus hieroglyphicus.
„ *intermedius*, Agassiz; *see* Stomechinus intermedius.
„ *lineatus*, Goldfuss; *see* Stomechinus lineatus.
„ *minutus*, Buckman; *see* Acrosalenia minuta.
„ *nodulosus*, Morris; *see* Polycyphus Normannus.
„ *nodulosus*, Goldfuss; *see* Magnotia nodulosa.
„ *perlatus*, Agassiz; *see* Stomechinus perlatus.
„ *perlatus*, var. *Forbesii*, Salter; *see* Stomechinus bigranularis.
„ *perlatus*, var. *germinans*, Wright; *see* Stomechinus germinans.
„ *petallatus*, McCoy; *see* Stomechinus gyratus.
„ *serialis*, Agassiz; *see* Stomechinus bigranularis.
„ *sinuatus*, Linnæus; *see* Clypeus Plotii.
„ *sulcatus*, Goldfuss; *see* Glypticus sulcatus.
Eucosmus decoratus, Agassiz; *see* Magnotia decorata.

Galerites depressus, Leske; *see* Holectypus depressus.
„ *hemisphæricus*, Agassiz; *see* Holectypus hemisphæricus.
„ *patella*, Lamarck; *see* Clypeus Plotii.
„ *radiatus*, Valenciennes; *see* Holectypus depressus.
„ *speciosus*, Goldfuss; *see* Holectypus speciosus.
„ *umbrella*, Lamarck; *see* Clypeus Plotii.
Galeropygus agariciformis, *Forbes* 465
GLYPTICUS, *Agassiz* 185
„ Burgundiacus, *Michelin* (F.S.) 189
„ hieroglyphicus, *Goldfuss* 186

PAGE

Glypticus sulcatus, *Goldfuss* (F.S.) 189
Goniopygus perforatus, Wright ; *see* Hemipedina perforata.
Grasia elongata, *A. Gras* 329

Hemicidaridæ, *Wright* 18, 68
Hemicidaris, *Agassiz* 69
,, alpina, *Agassiz* (F.S.) 104
,, *alpina*, Agassiz ; *see* Hemicidaris Wrightii.
,, Bravenderi, *Wright* 84
,, Brillensis, *Wright* 453
,, confluens, *McCoy* 92
,, crenularis, *Lamarck* (F.S.) 102
,, Davidsoni, *Wright* 96
,, diadema ta, *Agassiz* (F.S.) 103
,, granulosa, *Wright* 71
,, Hofmanni, *Roemer* (F.S.) 104
,, Icaunensis, *Cotteau* 90
,, intermedia, *Fleming* 92
,, Luciensis, *d'Orbigny* 78
,, minor, *Agassiz* 80
,, mitra, *Agassiz* 105
,, Purbeckensis, *Forbes* 98
,, pustulosa, *Agassiz* 73
,, radians, *Agassiz ; see* Acrosalenia radians.
,, Ramsayii, *Wright* 83
,, Stokesii, *Wright* 75
,, stramonium, *Agassiz* (F.S.) 103
,, *stramonium* (McCoy), Agassiz ; *see* Hemicidaris intermedia.
,, Thurmanni, *Agassiz* (F.S.) 104
,, Wrightii, *Desor* 88
Hemipedina, *Wright* 108, 143
,, Bakeri, *Wright* 149
,, Bechei, *Broderip* 144
,, Bonei, *Wright* 155
,, Bouchardii, *Wright* (F.S.) 170
,, Bowerbankii, *Wright* 145
,, corallina, *Wright* 163
,, Cunningtoni, *Wright* 167
,, Davidsoni, *Wright* 156
,, Etheridgii, *Wright* 148
,, Jardinii, *Wright* 146
,, Marchamensis, *Wright* 161
,, microgramma, *Wright* 159
,, Morrisii, *Wright* 166
,, Nattheimense, *Quenstedt* (F.S.) 170
,, perforata, *Wright* 151
,, Sæmanni, *Wright* (F.S.) 169

PAGE

HEMIPEDINA seriale, *Leymerie* (F.S.) 169
„ tetragramma, *Wright* 152
„ Tomesii, *Wright* 457
„ tuberculosa, *Wright* 164
„ Waterhousei, *Wright* 154
„ Woodwardi, *Wright* 158
HETEROCIDARIS, *Cotteau* 455
„ Wickense, *Wright* 456
HOLECTYPUS, *Desor* 259
„ arenatus, *Desor* (F.S.) 271
„ corallinus, *d'Orbigny* (F.S.) 270
„ depressus, *Leske* 260
„ *Devauxianus*, Cotteau ; *see* Holectypus hemisphæricus.
„ giganteus, *Desor* (F.S.) 272
„ hemisphæricus, *Agassiz* 264
„ inflatus, *Agassiz* (F.S.) 272
„ Mendelslohi, *Desor* (F.S.) 269
„ oblongus, *Wright* 267
„ planus, *Desor* (F.S.) 269
„ punctulatus, *Desor* (F.S.) 270
„ speciosus, *Goldfuss* (F.S.) 271
HOLOTHUROIDEA, *Wright* 3, 4
HYBOCLYPUS, *Agassiz* 291
„ agariciformis, *Forbes* 292
„ cordatus, *Wright* 296
„ *elongatus*, A. Gras ; *see* Grasia elongata.
„ gibberulus, *Agassiz* 298
„ *Marcou*, d'Orbigny ; *see* Hyboclypus stellatus.
„ ovalis, *Wright* 301
„ stellatus, *Desor* 303
Hypodiadema Etheridgii, Wright ; *see* Hemipedina Etheridgii.

MAGNOTIA, *Michelin* 190
„ decorata, *Agassiz* (F.S.) 195
„ Forbesii, *Wright* 191
„ Jurassica, *Cotteau* (F.S.) 194
„ Nodoti, *Michelin* (F.S.) 194
„ nodulosa, *Goldfuss* (F.S.) 194
Metaporhinus censoriensis, *Cotteau* (F.S.) 328
„ Michelinii, *Agassiz* (F.S.) 328
Milnia decorata, Haime ; *see* Acrosalenia decorata.

Nucleolites Agassizii, Wright ; *see* Clypeus Agassizii.
„ *altus*, McCoy ; *see* Clypeus altus.
„ *amplus*, Agassiz ; *see* Echinobrissus amplus.
„ *clunicularis*, Llhwyd ; *see* Echinobrissus clunicularis.
„ *crepidula*, Desor ; *see* Echinobrissus crepidula.

PAGE

Nucleolites decollatus, Quenstedt; *see* Hyboclypus agariciformis.
„ *dimidiata*, Desmoulins; *see* Echinobrissus dimidiatus.
„ *Edmundi*, Cotteau; *see* Echinobrissus clunicularis.
„ *excentricus*, Goldfuss; *see* Collyrites excentrica.
„ *excisus*, Quenstedt; *see* Hyboclypus gibberulus.
„ *gracilis*, Agassiz; *see* Echinobrissus gracilis.
„ *granulosus*, Goldfuss; *see* Disaster granulosa.
„ *Hugii*, Agassiz; *see* Clypeus Hugii.
„ *latiporus*, Agassiz; *see* Echinobrissus clunicularis.
„ *major*, Agassiz; *see* Echinobrissus major.
„ *Michelini*, Wright; *see* Clypeus Michelini.
„ *orbicularis*, Phillips; *see* Echinobrissus orbicularis.
„ *paraplesius*, Agassiz; *see* Echinobrissus dimidiatus.
„ *patella*, Lamarck; *see* Clypeus Plotii.
„ *planulatus*, Roemer; *see* Echinobrissus planulatus.
„ *pyramidalis*, M'Coy; *see* Echinobrissus clunicularis.
„ *scutatus*, Lamarck; *see* Echinobrissus scutatus.
„ *semisulcata*, Phillips; *see* Pygaster semisulcatus.
„ *Solodurinus*, Agassiz; *see* Nucleolites Mülleri.
„ *Sowerbyi*, Defrance; *see* Echinobrissus clunicularis.
„ *Terquemi*, Agassiz; *see* Echinobrissus clunicularis.
„ *Thurmanni*, Desor; *see* Echinobrissus clunicularis.
„ *Woodwardii*, Wright; *see* Echinobrissus Woodwardii.

OPHIUROIDEA, *Wright* 3, 5

PEDINA, *Agassiz* 108, 171
„ arenata, *Agassiz* (F.S.) 179
„ aspera, *Cotteau* (F.S.) 181
„ Bakeri, *Wright; see* Hemipedina Bakeri.
„ Charmassei, *Cotteau* (F.S.) 181
„ *Etheridgii*, Wright; *see* Hemipedina Etheridgii.
„ Gervillii, *Desmoulins* (F.S.) 179
„ Michelini, *Cotteau* (F.S.) 180
„ rotata, *Wright* 173
„ Smithii, *Forbes* 176, 459
„ sublævis, *Agassiz* (F.S.) 180
Pileus hemisphæricus, Desor; *see* Pygaster pileus.
POLYCYPHUS, *Agassiz* 196
„ Corallinus, *Cotteau* (F.S.) 201
„ Deslongchampsii, *Wright* 199
„ distinctus, *Agassiz* (F.S.) 202
„ *nodulosus*, Goldfuss; *see* Polycyphus Normannus.
„ Normannus, *Desor* 197
„ stellatus, *Agassiz* (F.S.) 201
PSEUDODIADEMA, *Desor* 108
„ æquale, *Agassiz* (F.S.) 140

PAGE

PSEUDODIADEMA affine, *Agassiz* (F.S.) 140
„ Bailyi, *Wright* 120
„ Bakeriæ, *Woodward* 121
„ complanatum, *Agassiz* (F.S.) 136
„ depressum, *Agassiz* 112
„ hemisphæricum, *Agassiz* 127
„ homostigma, *Agassiz* 118
„ inæquale, *Agassiz* (F.S.) 137
„ lobatum, *Wright* 456
„ magnagramma, *Wright* (F.S.) 138
„ mamillanum, *Roemer* 132
„ Mooreii, *Wright* 110
„ Orbignyanum, *Cotteau* (F.S.) 139
„ Parkinsoni, *Desor* 114
„ pentagonum, *McCoy* 115
„ placenta, *Agassiz* (F.S.) 138
„ planissimum, *Agassiz* (F.S.) 141
„ radiatum, *Wright* 131
„ subangulare, *Goldfuss* (F.S.) 141
„ subcomplanatum, *d'Orbigny* (F.S.) 136
„ superbum, *Agassiz* (F.S.) 137
„ tetragramma, *Agassiz* 139
„ vagans, *Phillips* 123
„ versipora, *Phillips* 124
„ *Nodoti*, Cotteau ; *see* Pedina Smithii.
PYGASTER, *Agassiz* 273
„ *brevifrons*, McCoy ; *see* Pygaster semisulcatus.
„ conoideus, *Wright* 278
„ dilatatus, *Agassiz* (F.S.) 288
„ *Edwardseus*, Buvignier ; *see* Pygaster umbrella.
„ Gresslyi, *Desor* (F.S.) 287
„ laganoides, *Agassiz* (F.S.) 287
„ macrocyphus, *Wright* (F.S.) 290
„ macrostoma, *Wright* 463
„ Morrisii, *Wright* 280
„ patelliformis, *Agassiz* (F.S.) 288
„ pileus, *Agassiz* (F.S.) 289
„ semisulcatus, *Phillips* 275, 463
„ *sublævis*, McCoy ; *see* Hyboclypus agariciformis.
„ tenuis, *Agassiz* (F.S.) 290
„ umbrella, *Agassiz* 282
PYGURUS, *d'Orbigny* 391
„ acutus, *Agassiz* (F.S.) 409
„ Blumenbachii, *Koch* and *Dunker* 400
„ costatus, *Wright* 397
„ *Davoustianus*, Davoust ; *see* Pygurus Michelini.
„ depressus, *Agassiz* (F.S.) 409

PAGE

PYGURUS *emarginatus*, Phillips; *see* Clypeus subulatus.
„ *giganteus*, Wright; *see* Pygurus Hausmanni.
„ Hausmanni, *Koch* and *Dunker* 405, 467
„ Icaunensis, *Cotteau* (F.S.) 411
„ Jurensis, *Marcou* (F.S.) 412
„ Marmonti, *Beaudouin* (F.S.) 410
„ Michelini, *Cotteau* 392
„ orbiculatus, *Leske* (F.S.) 410
„ pentagonalis, *Phillips* 395
„ Phillipsii, *Wright* 403
„ tenuis, *Desor* (F.S.) 411

RABDOCIDARIS, *Desor* 54
„ maxima, *Goldfuss* 55, 65
„ Moraldina, *Cotteau* 54
„ nobilis, *Goldfuss* (F.S.) 65
„ Orbignyana, *Desor* (F.S.) 66

SALENIADÆ, *Wright* 19, 226, 460
SAVIGNYA, *Desor* 108
SIPUNCULOIDEA, *Wright* 3
SPATANGIDÆ, *Wright* 21
Spatangites bicordatus, Leske; *see* Collyrites bicordata.
„ *carinatus*, Leske; *see* Collyrites carinata.
„ *ovalis*, Leske; *see* Collyrites bicordata.
„ *ovalis*, Leske; *see* Collyrites ovalis.
„ *capistratus*, Goldfuss; *see* Collyrites capistrata.
Spatangus depressus, Leske; *see* Echinobrissus scutatus.
„ *ovalis*, Leske; *see* Collyrites bicordata.
STOMECHINUS, *Desor* 203
„ apertus, *Desor* (F.S.) 222
„ bigranularis, *Lamarck* 210
„ Caumonti, *Desor* (F.S.) 221
„ excavatus, *Goldfuss* (F.S.) 223
„ germinans, *Phillips* 204
„ gyratus, *Agassiz* 215
„ intermedius, *Agassiz* 208
„ lineatus, *Goldfuss* (F.S.) 224
„ microcyphus, *Wright* 213
„ multigranularis, *Cotteau* (F.S.) 220
„ nudus, *Wright* 217
„ perlatus, *Desmarest* (F.S.) 224
„ Orbignyanus, *Cotteau* (F.S.) 223
„ polyporus, *Agassiz* (F.S.) 221
„ semiplacenta, *Desor* 225
„ serialis, *Agassiz* (F.S.) 223
„ *sub-conoideus*, Desor; *see* Stomechinus germinans.

PAGE

Stomechinus Robinaldinus, *Cotteau* (F.S.) 222
„ Vacheyi, *Cotteau* (F.S.) 220
Tetragramma planissimum, Agassiz (F.S.); *see* Pseudodiadema planissimum.

FOREIGN SPECIES OF THE FOLLOWING GENERA NEARLY ALLIED TO BRITISH FORMS, BUT WHICH HAVE NOT YET BEEN FOUND IN THE ENGLISH OOLITES.

Acrosalenia . . . . . 253—257
Cidaris . . . . . 59—64
Clypeus . . . . . 386—388
Collyrites . . . . . 324—328
Diplocidaris 67
Disaster . . . . . 323—324
Echinobrissus . . . . . 356—359
Glypticus 189
Grasia 329
Hemicidaris . . . . . 102—105
Hemipedina . . . . . 169—170
Holectypus . . . . . 269—272
Magnotia . . . . . 194—195
Metaporhinus . . . . . 328—329
Pedina . . . . . 179—182
Polycyphus . . . . . 201—202
Pseudodiadema . . . . . 136—142
Pygaster . . . . . 287—290
Pygurus . . . . . 409—412
Rabdocidaris . . . . . 65—66
Stomechinus . . . . . 220—225

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A MONOGRAPH

OF THE

BRITISH FOSSIL CRUSTACEA,

BELONGING TO THE

ORDER MEROSTOMATA.

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PREFACE.

Since, of late years, the conclusion has become very generally accepted among Naturalists that the development of the embryo of any animal is but a recapitulation of the ancestral history of the species to which it belongs, a new impulse has been imparted alike both to embryological and palæontological research, for each furnishes most valuable and independent evidence by which to demonstrate the correctness or fallibility of the doctrine of Evolution.

But whilst, on the one hand, the reconstruction of the pedigree of a group from the developmental history of its existing members is admittedly fraught with difficulties—for the series of developmental stages of the individual organism probably never presents more than an abbreviated and condensed summary of ancestral conditions, whilst the summary itself is oftentimes strangely modified—on the other hand, the palæontologist is only too well aware that the materials at his command merely enable him to furnish an outline of the ancestry of many of the groups most largely represented at the present day.

There is, perhaps, no group among the fossil Crustacea which affords such ample materials for comparison with recent forms as the order Merostomata.

Extending back in time to the Lower Silurian Rocks, these ancient forms not only portray the larval stages of the highest forms of living Crustacea, but they also foreshadow the incoming of the air-breathing Arachnida, whose ancestors they probably were.

Another interesting feature of the order is its bipartite division into brachyuran and macrouran forms which exemplify the crawling and swimming types, by the soldering together of the body-segments in the one (*Limulus*), and the retention of free movement in the somites of the other (*Pterygotus*).

Numerous species of the ancient extinct long-bodied Eurypterida have been met with and described by Prof. James Hall in America, by Fischer and Nieszkowski in Russia and Sweden, and by Huxley and Salter and by myself in Britain.

The most perfect specimens of the genera *Slimonia*, *Pterygotus*, and *Eurypterus*, have been obtained by Dr. J. Slimon, of Lesmahagow, Lanark. The largest known remains, representing specimens from five to six feet in length, are from the Old Red Sandstone of Forfarshire, belonging to the great *Pterygotus anglicus*

and *Stylonurus scoticus*, obtained by James Powrie, Esq., F.G.S., of Reswallie, Forfar.

In the Upper Silurian we have one English genus, *Hemiaspis*, and three Russian forms, *Exapinurus*, *Pseudoniscus*, and *Bunodes*, which, like the Decapoda-Anomoura, serve partially to bridge over the interval between the brachyuran *Limuli* and the macrouran *Pterygoti*, the segments of the hind-body being partially developed.

The Eurypterida are eminently larval in their characteristics, and recall to mind the earliest stages in the development of the living Brachyuran Decapod (e. g. *Carcinus mœnas*), in which the principal locomotory organs are the maxillipeds, the branchiæ (if developed) being external and thoracic, the abdominal somites in both being destitute of appendages. Like the larva of these higher forms, too, they have doubtless undergone further modification, and so in the course of ages this primitive type has disappeared. The latest representative of this extinct order has been found in the Lower Carboniferous series of West Lothian, the *Eurypterus Scouleri*, which, however, differs greatly from all the other earlier forms.

The brachyuran type, or Xiphosura, are represented by a very minute form with free thoracico-abdominal somites in the Upper Silurian of Lesmahagow, Lanarkshire, the *Neolimulus falcatus*, and by numerous species in the Coal-measures of Great Britain and Ireland, the United States, Germany, and Bohemia. Some of these forms belonging to the genus *Bellinurus* had free thoracic somites, and others, like *Prestwichia rotundata*, forcibly remind one of the free-swimming larvæ of the modern King-Crab. In the Oolitic period the *Limuli* seem to have already attained to the greatest development of which they were capable, and to be as highly differentiated as their modern representatives, *Limulus polyphemus* and *L. moluccanus*.

The Ostracoda, Phyllopoda, and Xiphosura are good examples of persistent types of Crustacea. They are orders the members of which have branched out long since into bye-ways of their own, where, being checked from further progress, they have by their great tenacity of life and large powers of reproduction held their ground through the long lapse of ages from Cambro-Silurian times to the present day, whilst higher orders have been modified or swept away.

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London, S.W. ;
21*st February*, 1878.

A MONOGRAPH

OF THE

BRITISH FOSSIL CRUSTACEA

OF THE

ORDER MEROSTOMATA.

PART V.

Sub-Order—XIPHOSURA, Gronovan.

Introduction.

In the first part of this Monograph (p. 24) I have alluded to the proposal made by Professor McCoy, in 1849,[1] to unite in one tribe of the order Entomostraca, the recent and fossil *Limulidæ*, and the extinct genera of *Pterygotus*, *Eurypterus*, &c.

This generalization, however, failed to meet with acceptance and adoption, having been founded upon an incorrect view of the structure of the fossil forms it associated together.[2] Nor can it be doubted that the arrangement was based on conjecture rather than upon a minute acquaintance with the anatomy of those extinct genera *Pterygotus* and *Eurypterus*, then only known in England by extremely fragmentary remains.[3]

In the important memoir by Messrs. Huxley and Salter, published in 1859, Professor Huxley thus expressed his views on the union of the two groups :

"The *Pœcilopoda* are, I believe, the only *Crustacea* which possess antennary organs like those of *Pterygotus*, and, like them, have the gnathites converted into locomotive

[1] See 'Ann. and Mag. Nat. Hist.,' 2nd series (1849), vol. iv, p. 393, and Lyell's 'Manual,' 1855, 5th edition, p. 420.

[2] See Introduction to Huxley and Salter's 'Monograph on the Eurypteridæ,' 1859, p. 7, and H. Woodward's paper "On the Structure of the Xiphosura having reference to their Relationship with the Eurypterida," 'Quart. Journ. Geol. Soc.,' 1867, vol. xxiii, p. 28.

[3] See McCoy's restoration of *Pterygotus* (reproduced from Lyell's 'Manual'), Part I, p. 24, of this Monograph.

organs, want the appendages to the sixth abdominal somite, and present on some parts of the body a remotely similar sculpture. In this order, however, we find but a small labrum—a rudimentary metastoma—a very differently constructed body, and a large number of appendages, both thoracic and abdominal, characters which effectually preclude the association of the extinct *Crustacea* under discussion with this type." He adds in a note: "If the abdominal somites of the Carboniferous *Bellinurus*, &c., were really free, they would present a certain approximation to the *Pterygoti*. Indeed, the evidence that these Carboniferous Crustacea were true *Pœcilopoda* is, to my mind, anything but conclusive" (op. cit., p. 34).

One serious difficulty in homologising the structures of *Limulus* and *Pterygotus*, which no doubt weighed strongly with Messrs. Huxley and Salter against the classification proposed by McCoy, arose from their having erroneously placed the large bilaterally symmetrical plate (which we now know to be the thoracic plate or operculum) on the front ventral surface of the head-shield, and named it "the conjoined metastoma and labrum."[1] This mistake was, however, pointed out and corrected later on in the same year (1859) by Professor James Hall, of Albany, U.S. (in his 'Palæontology of the State of New York'),[2] whose researches into the structure and affinities of *Eurypterus*, *Pterygotus*, and *Limulus*, have led him to the conclusion that a close relationship exists between them, and in this opinion he is supported by Professor Agassiz,[3] who believes them to belong even to the same order. "He regards the antennal system as entirely absent. The organs of locomotion belong to the cephalic region; and while externally they perform the functions of feet, they are, at the base, organs of manducation. The central organ indicated as a locomotive appendage[4] (by Hall), Professor Agassiz regards as similar to the appendage attached to the membranaceous feet, behind the swimming feet of *Limulus*, and instead of being double is anchylosed as in young *Limulus*."

Three years later I devoted much time to the examination of these forms, and without being aware of the already published views of Professors Hall and Agassiz, I arrived independently at the same conclusions with them. Fortunately, however, just as I was about to publish them in 1863,[5] I became aware of Professor Hall's observations, and was delighted to discover, that, if not the first to interpret the structure and affinities of these interesting forms, I had at least excellent confirmation as to the correctness of my views.

In the same year (1863) Mr. W. Hellier Baily, F.G.S., Acting Palæontologist to the Geological Survey of Ireland, published his "Remarks on some Coal-measure Crustacea

[1] See Mr. Salter's restoration of *Pterygotus anglicus*, made in 1859 for Murchison's 'Siluria,' and reproduced in Part I, p. 27, of this Monograph.

[2] Hall, 'Natural Hist. of New York: Palæontology' (1859), vol. iii, p. 393.

[3] Op. cit., p. 394.

[4] The median appendage of the thoracic plate or operculum.

[5] See article "On the 'Seraphim' (*Pterygotus anglicus*) and its Allies," by H. Woodward, in 'Intellectual Observer,' 1863, vol. iv, p. 229 (with a plate and a series of woodcuts).

belonging to the genus *Bellinurus*, König, with descriptions of two new species from Queen's County, Ireland."[1] Mr. Baily points out the importance of maintaining König's genus *Bellinurus*,[2] which had been set aside by Buckland, in his 'Bridgewater Treatise,' who referred this Coal-measure form to the modern genus *Limulus*.[3] He defines them as Entomostraca of the legion Pœcilopoda, and order Xiphosura. Mr. Baily also approves and cites Pictet's arrangement, who places *Limulus*, *Halycine*, *Bellinurus*, and *Pterygotus* in the order Xiphosura.[4]

In a communication to the Geological Society in 1866,[5] I have endeavoured to show the grounds upon which my classification of the Eurypterida and Xiphosura in the order Merostomata is based; and it may perhaps be desirable before proceeding with the descriptions of the genera and species belonging to the remaining sub-order, briefly to recapitulate the reasons for adopting and adhering to it.

The Sub-orders Eurypterida and Xiphosura compared.

I.—In the division of the Merostomata, already described, we have seen that in *Pterygotus* (Part I, Pl. VIII) and *Eurypterus* (Part IV, p. 132, woodcut, fig. 40) the animal consists of a more or less semicircular head-shield (*cephalon*, Bates;[6] *cephaletron*, Owen[7]), bearing in the centre the ocelli, and also a larger pair of marginal or subcentral compound eyes upon its dorsal aspect; whilst beneath, upon its ventral aspect, we find the oral aperture, in front of which arise a pair of chelate (in *Pterygotus*) or simple antennæ (in *Eurypterus*, *Slimonia*,[8] and *Stylonurus*[9]), followed by three pairs of more or less slender monodactylous pedipalps, and lastly, by a pair of very broad (spatulate) and powerful swimming-feet, whose basal joints subserve the office of mandibles and maxillæ.

The general arrangement of these oral appendages is alike in all the Eurypterida save that in *Pterygotus*, in which the antennæ are chelate (serving as powerful organs of prehension); the basal joint does not subserve the function of manducation, but in *Slimonia* (Part III, Pl XVII, fig. 3), *Stylonurus* (Part IV, p. 131, fig. 39), and *Eurypterus* (Part IV, p. 132, fig. 40), in which the antennæ are small and simple, the

[1] See 'Ann. and Mag. Nat. Hist.,' 1863, 3rd series, vol. xi, p. 107, pl. v.

[2] König's 'Icones Fossilium Sectiles,' 1820, pl. xviii, fig. 230.

[3] Buckland's 'Bridgewater Treatise,' 1836, vol. i, p. 396, vol. ii, p. 77, pl. xlvi", fig. 3.

[4] Pictet's 'Traité de Paléontologie,' ed. 2, 1854.

[5] See 'On some points in the Structure of the Xiphosura having reference to their Relationship with the Eurypterida,' by H. Woodward, 1876, vol. xxiii, p. 28, pls. i and ii (read November 21st, 1866).

[6] See Introduction, Part I, p. 5.

[7] See 'Anatomy of the American King-Crab (*Limulus polyphemus*),' 1873, by Prof. Owen, F.R.S., p. 463; 'Trans. Linnean Soc.,' vol. xxviii, part iii.

[8] See *ante*, Part III, p. 109, fig. 31.

[9] See *ante*, Part IV, p. 131, fig. 39.

basal joints are always subservient to alimentation; whilst in *Stylonurus* two of the most posterior pairs of appendages fulfil the function of natation, being developed into long slender oars, which upon occasion might also have served as claspers by which to anchor itself to any floating body when resting or in quest of food.

Immediately behind the mouth and attached to the hinder portion of the head, with its free border extending forward so as to overlap the bases of the maxillipeds and the oral aperture, is the great metastoma or post-oral plate, which is present in all the EURYPTERIDA.

The compound head is succeeded by twelve free and movable segments, of which, only the first two (?) bear appendages, the succeeding somites being apparently destitute of any organs. These post-cephalic appendages consist of two or three pairs of lamelliform plates (the modified thoracic[1] limbs) united together down the mesial line and attached to the ventral surface of the somites, against which they fit when closed, thus serving as defensive coverings or sheaths to the organs of generation and respiration, which they bear upon their inner and upper surface (see *ante*, Part III, pp. 114—119, figs. 35—38).

The twelve free segments are terminated by a post-anal plate (or "telson") broadly lanceolate or bilobed in *Pterygotus* (Parts I and II) and *Slimonia* (Part III), and ensiform in *Eurypterus* and *Stylonurus* (Part IV).

Viewed as a whole, the EURYPTERIDA present, to my mind, the clearest evidence of a group essentially fitted for easy and tolerably rapid motion, their long and gradually tapering body undoubtedly enclosing within it a correspondingly compact and solid mass of muscles, by which to move it at will through the water, the broad hastate telson (in *Pterygotus* and *Slimonia*) serving both as a powerful propeller and also to depress or elevate its course, whilst its great spatulate swimming-feet would increase its speed or change its lateral direction; lastly, the chelate antennæ seem admirably fitted to seize its prey either when overtaken or approached by stratagem.[2]

All the genera belonging to this remarkable Palæozoic group, the EURYPTERIDA, are now extinct. (See *ante*, Parts I—IV.)

II.—In the second division of the MEROSTOMATA, about to be described, the XIPHOSURA, of which the modern *Limulus* may serve as the type (see Part I, Pl. IX, fig. 1, and Pl. XXXIV—XXXVI), the head is composed of a broad, semilunar shield, the dorsal surface of which rises in the centre, forming a median ridge, upon the fore part of which,

[1] *Thoracetron*, Owen, op. cit.

[2] It is highly probable that the chelate antennæ in *Pterygotus* may have also fulfilled the function of claspers in the males, being perhaps longer and stronger than in the female (as we find is commonly the case with the chelate (3rd thoracic) pair in Decapod Crustacea); or they may have been simple palpi in the female, in which case the genera *Slimonia* and *Eurypterus* with simple antennæ would have to be considered as females, and *Pterygotus* with its chelate antennæ as a male, the opposite sex in each case being unknown, or undetermined.

just at the highest central point, the ocelli are placed (Pl. XXXVI, fig. 1, *a* 1), whilst the larger compound eyes (Pl. XXXV, fig. 2, and Pl. XXXVI, fig. 1, I, I,) are situated nearer the sides of the shield, and occupy a point midway upon the two lateral ridges which encircle the central elevated tract or glabella.[1] The front of this great buckler slopes rapidly down to the curved anterior border, the edge of which is strengthened by a bead-like rim. The two genal or lateral portions of the shield are widely produced backward, considerably over-reach the margins of the succeeding thoracic segments, and terminate upon each side in a broad recurved spine

The posterior border of the head-shield is deeply emarginated, and is articulated to the anterior border of the thoracico-abdominal segments by a broad median joint capable of considerable flexure, the post-cephalic segments in the adult modern *Limulus* being soldered together into one nearly homogeneous buckler, and only indicating their original free and movable condition in the young state by the alternation of spines and rounded indentations on each lateral margin, in the hollows of which a series of six spines are articulated on either side in the adult (see Pl. IX, fig. 1, Pl. XXXV, fig. 1 B, Pl. XXXVI, fig. 1 B). In the deep notch formed by the prolongation of the two latero-posterior angles of the hinder border is articulated the powerful triangular "telson" or tail-spine, which often more than equals the length of the rest of the body. The post-cephalic shield is strongly trilobed, and marked by a double row of small oblong indentations corresponding with the entopophysial processes, which are developed from the inner and under surface to support the branchigerous feet.

The length of the head-shield and of the post-cephalic shield is nearly equal, but the former is much broader than the latter.

Beneath the head-shield, which is a double buckler—between the inner and the outer

[1] In the Introduction to his 'Monograph on the British Trilobites,' Pal. Soc., Part I, 1864, p. 10, Mr. Salter observes, "The curious so-called *facial suture*, a line of division which is only faintly indicated in *Limulus*, and which has, perhaps, no other representative in the whole Crustacean class, sufficiently distinguishes the Trilobite."

The relative position of the eyes in *Limulus* upon the ridge which circumscribes the glabella or central portion of the shield favours this homology, and although no actual line of suture can be traced dividing the general portion of the head-shield from the glabella in *Limulus*, nor any indication of a disposition to divide along this line, as is commonly the case in Trilobites, we may conclude that they do actually correspond.

Nor is this structure of the head-shield so exceptional as Mr. Salter had supposed. For, whilst Professor Dana and Mr. Spence Bate have shown that the antennal segment constitutes the anterior and upper portion, and the mandibular segment forms the posterior and lower portion of the carapace in the Macrouran and Brachyuran Decapod, the latter ('Annals and Mag. Nat. Hist.,' 1855, 2nd series, vol. xvi, p. 36) has affirmed that the suture which traverses the lower surface of the carapace of the latter forms the line of demarcation between the third and fourth somites, and is homologous with the cervical suture in the Macroura, with that which traverses the dorsal surface of the cephalon in several genera of Trilobites, and, we would add, of *Limulus* also. In this view of the structure of the head in the Crustacea we cordially agree. [See also Spence Bate, 'Brit. Assoc. Reports,' 1875, Bristol, p. 46.]

shell of which the soft parts of the animal are completely enclosed (see Pl. XXXIV, figs. 1 and 2, and Pl. XXXVI, fig. 1)—the gnathopods or jaw-feet are ranged. These organs fulfil, as in the Eurypterida, the combined functions of locomotion, prehension, and so much of the sorting and mastication of the food as is needful before deglutition. They are all chelate, the most anterior pair, Pl. IX, figs. 1, 2 (the antennules), is the smallest, and is præ-oral, being attached on either side of a minute epistome, the antennules are not provided with a spinose coxal joint, as is the case with the five succeeding pairs. The second pair is subject to modification in the males of the American species, Pl. IX, fig. 1 *a* (*Limulus polyphemus*), and the second and third in the males of the Moluccan species (*L. moluccanus*). The sixth pair of limbs have stronger maxillary joints, and at the distal extremity (Pl. XXXIV, fig. 4) bear upon the ante-penultimate joint a series of lamelliform plates, which, when spread out, greatly assist the animal both in burrowing and walking

This, with a small bifid metastome,[1] completes the circumoral appendages.

Behind the mouth are placed six broad, lamelliform appendages, the first of which bears upon its upper and inner surface the ovaries or reproductive organs, and the remaining five the branchiæ (see Pl. XXXV, figs. 1, 6, and 8).

The following details of the internal structure of the living *Limulus* I take from Professor Owen's valuable Monograph "On the Anatomy of the American King Crab, *Limulus polyphemus*" ('Trans. Linnæan Soc.,' 1872, vol. xxviii, pp. 459—506), to whose kindness, and also to the courtesy of the President and Council of the Linnæan Society, I am indebted for permission to reproduce the subjects forming Plates XXXIV, XXXV, and XXXVI of the present Monograph.

On the Anatomy of the American King-Crab, *Limulus polyphemus*, Latr. By Professor Owen, C.B., F.R.S., F.L.S.

§ 1. "*Muscular system.*—The parts sent inward from the crust or exoskeleton are those that afford attachment to muscles, and those which also form or contribute to the joints of the articulate appendages. They are termed 'entapophyses' and 'apodemes.' The 'apodemes' that relate to the cephaletral[2] limbs (Pl. XXXVI, II—VI) are broader and more complex than those of the thoracetron (ib., VII—XIII). The most conspicuous entapophyses are the following:—A pair of oblong, lamelliform processes descend from the segment confluent with, and forming part of the hind border of the cephaletron[2] at the parts indicated by the ciliate depressions. Six pairs of similar, but rather smaller

[1] Named by Prof. Owen "chilaria," from Χειλάριον, a small lip.

[2] Prof. Owen has proposed in his 'Memoir,' from which we quote so largely, the use of the terms "cephaletron" for the seven anterior somites forming the *cephalic* shield; "thoracetron" for the seven succeeding somites forming the *thorax* or middle body; and he applies Spence Bate's term "pleon" for the hinder *apodal* portion of the posterior shield, or *abdomen*, "including therein the part which Spence Bate calls 'telson,' constituting the characteristic 'tail-spine' of the present singular genus."

processes project into the cavity of the thoracetron, from the inner surface of the parts indicated by the oblong depressions. These serve to give attachment to and augment the force of muscles. Analogous entapophyses are developed in most of the articulations of the limbs (Pl. XXXIV, fig. 5 *c*, *e*, *g*) for a like purpose. All these internal processes assume more or less of a cartilaginous character, losing the hardness and colour of the outer crust as they extend inwards.

"The main movements of *Limulus* in locomotion are those of inflection and extension of the 'cephaletron'[1] upon the thoracetron,[1] and of the tail-spine upon the latter, and reciprocally.

"The fixed points upon which the cephaletral muscles act upon the thoracetron are afforded not only by the apodemata and entapophyses, but also by the representative of an internal skeleton. This (Pl. XXXIV, figs. 1 and 2 *h*) is situated partly in the angles between the gullet and the stomach, thence extending backward a short way along the interval between the beginning of the intestine and the neural axis. It is an oblong, subquadrate plate of sclerous or fibro-cartilaginous tissue, and is chiefly related to the attachment of muscles (Pl. XXXV, fig. 5). It was likened by its discoverer, Straus Dürckheim, to an internal cartilaginous sternum, and may answer to the part which he so terms in the Arachnida. I shall refer to it, without any wider homological signification, as the 'entosternon.'

"*Levatores thoracetri.*—The extensors or, more properly, 'levators' of the thoracetron are a pair of powerful muscles, the fibres of which rise from the low inner ridges indicated or formed by the longitudinal mediilateral grooves or inflections of the carapace.[2] This feature in the accentuation of the upper crust of the 'cephaletron' relates to such favorable condition of origin of the 'levatores thoracetri.' The pair come into contact at the median line, filling the hollow of the roof, of which that line is the mid-ridge; their longitudinal fibres (Pl. XXXIV, fig. 1 *m*, 1) intervene between it and the pericardium as they pass backward to be inserted into the anterior and upper transversely convex process of the 'thoracetron' (*g*), which enters the correspond arch (*f*) of the 'cephaletron.'

"*Depressores thoracetri.*—The flexors or 'depressors' of the 'thoracetron' rise from the dorsal surface of the hinder third of the entosternon (Pl. XXXV, fig. 5 *m*, 2), divide as they pass backward into two groups or a pair, the fibres of which ascend obliquely on each side the intestine, and subdivide into fasciculi, to be inserted into the entapophyses of the thoracetron.

"*Prætrahentes entosterni.*—The power of the 'entosternon' as a fixed point or fulcrum is provided for by other muscles. A strong, longitudinal, subdepressed fasciculus rises from the inner surface of the fore part of the cephaletron on each side, the fibres of which slightly converge as they pass backward to be inserted into the anterior angles of

[1] See Note 2, page 186.

[2] The corresponding grooves rendering *Asaphus*, &c., "trilobitic" most probably indicate analogous ridges or entapophyses for the flexor muscles of the segments.

the entosternon (Pl. XXXV, fig. 5 *m*, 3).[1] They tend to draw that part forward, and resist the backward displacement of it, which would otherwise ensue in the action of the 'depressores thoracetri' (*m*, 2). The '*prætrahentes entosterni*' are the main origins or 'fixed points,' functionally, of the great muscles, made 'digastric' by the intervention of the entosternal fibro-cartilage, which depress the thoracetron; when the insertional lamella of the '*depressores thoracetri*' become fixed points, they act through the medium of the entosternon as origins of the digastric muscles deflecting the cephaletron. In like manner, when the insertions of the '*levatores thoracetri*' become the fixed points or origins, those muscles will oppose the '*depressores cephaletri*,' and become '*levatores*' of that part.

"*Levatores antici sterni*.—But the singular structure which acts functionally as 'endoskeleton' in *Limulus* has additional powers given to it by muscles which, like the mainstay of a mast, steady it in the transverse or lateral directions. From near the fore part of the dorsal surface of the entosternon diverge a pair of sclerous processes, which become tendons of a pair of muscles (Pl. XXXV, fig. 5 *m* 4)[2] about half the size of the '*protractores*' (ib., fig. 5 *m* 3), and which have their fixed points in the antero-lateral part of the cephaletron. The '*levatores*,' by their direction, tend to raise and draw forward the entosternon, and so add their power to the protractors when these muscles are made to act in combination with the '*depressores thoracetri*,' but to the degree in which their oblique course would tend, if one of the pair acted singly, to pull the entosternon sideways, their combined action would add to its fulcral power in relation to the movements of the two chief divisions of the body.

"*Levatores laterales entosterni*.—The steadying of the entosternon is more directly attained by a series of fibres which, rising from ridges due to the inflection of the lateral longitudinal grooves of the cephaletron, descend and converge to be inserted into the posterior half of the lateral borders of the entosternon (ib., *m* 5).

"*Levatores postici entosterni*.—Fasciculi from the dorsal surface (Pl. XXXV, fig. 5, *m* 6), which seem to be the fore part of the series of '*depressores thoracetri*,' ascend, as they retrograde, to be inserted into the lamelliform entapophyses rising from the hind border of the cephaletron, which seem to initiate anteriorly the series of shorter and smaller ones descending from the thoracetron. With the insertion, or rather origin, of the above entosternal muscles, their action would be to retract and raise the entosternon.

"The functions of these '*levatores entosterni*,' in relation to the fixation of the endoskeleton, are more especially in opposition to muscles arising from its lower and lateral parts to be inserted into basal entapophyses of the five posterior pairs of cephaletral limbs. But the principal muscles acting on the basal joints of these members arise from the

[1] J. vander Hoeven, 'Recherches sur l'Histoire naturelle et l'Anatomie des Limules,' fol. 1838, p. 47, pl. iii, fig. 7 *b*.

[2] Ibid., fig. 7.

'apodemata' or inflections of the ventral crust (Pl. XXXVI, fig. 1, II—VI), forming, or rising from, the articular cavities in the cephaletral plastron for those limb segments.[1]

"The '*levatores telsi*,' if I may be permitted to Latinise Spence Bate's term for the 'tail-spine,' rise from the upper median lateral parts of the inner surface of the thoracetron; the median fasciculi form one elongated muscle (Pl. XXXIV, fig. 1, *m* 7), which is inserted into the upper basal process, and directly tends to raise the spine; there are two shorter lateral masses (*ib.*, *m* 8), converging to be inserted into the same process, but which, if acting independently, would draw the spine outwards as well as upwards. Both median and lateral muscles acting together would raise the spine forcibly, or if the spine were the fixed point, and the thoracetron, depressed at an angle therewith, would tend to raise that part.

"*Depressores telsi*.—Two shorter and broader but powerful muscles (*ib.*, *m* 9), having the double oblique or penniform disposition of fibres, rise from the lower terminal part or segment of the thoracetron (*ib.*), and converge to be inserted into the sides of the basal entapophyses from below the articular condyles of the tail-spine. These, combining in action, depress the tail-spine; their lateral portion, combining with the corresponding one of the *levator telsi*, draws the spine to that side. When the spine was fixed the muscles would act as flexors, extensors, or adductors of the thoracetron.

"Muscular fasciculi for the protraction and retraction of the thoracetral appendages rise from the apodemata of that division of the body.

"*Protractores branchipedum*.—The limb-plates of each lateral moiety of the broad gill-bearing lamella has two principal muscles; one, arising from the outer part of the apodeme in advance, subdivides into fasciculi, which descend, penetrating the fore or under surface of the gill-limb (Pl. XXXIV, fig. 1, IX—XIII), and radiate therein to be attached to the several segments. These fibres protract the limb, change its recumbent for the erect position, and in that movement separate the gill-plates and facilitate the flow of water through their interspaces.

"*Retractores branchipedum*.—These muscles rise from the base of the apodeme of their own gill-foot, near the place of articulation of the latter, and spread upon the hinder, inner, or upper surface of the proximal lamelliform joint before penetrating the interior of the succeeding ones. They retract or draw up the gill-feet, approximate and press together the gill-plates, and squeeze out the water from their interspaces. The insertional fibres of this muscle are shown on the anterior thoracetral lamelliform limb, which serves as a cover or 'operculum' to the genital outlets (Pl. XXXV, fig. 6, *m* 11).

"Some small fasciculi, combining their insertions with the proper muscles of the branchipeds, have attachments to the thoracetral entapophyses, and seem to combine a levator action upon the branchipeds with that of the '*depressores thoracetri*.'

"In the cephaletral limbs (III—VI, Pls. XXXIV and XXXV) the haunch-joint

[1] J. vander Hoeven, op. cit., pl. iii, fig. 10, *b*, *c*.

(*coxa*, 1) is of great transverse extent, and besides affording insertion to the apodemal muscles, which forcibly work the carding-plate, or 'palpus' (Pl. XXXIV, figs. 2—5, *p*), gives origin to muscles acting on the second joint or 'basis' (*ib.*, *ib.*, 2).

"*Extensor basis pedis.*—One of these, of small size, is an extensor of the 'basis' (Pl. XXXIV, fig. 5, *a*), but only in a slight degree.

"The '*flexor basis*' (*ib.*, *b*) is a larger, especially broader, muscle, and bends the 'basis' forcibly upon the 'coxa' or first joint.

"*Flexor merii cnemiique.*—The muscle (*ib.*, *d*) arising from the 'basis' (2) is supplemented by other fibres from the 'merion' or third joint (3), proceeding penniform-wise to an entapophysis (*c*), attached to the base of the 'cnemion' or fourth joint (4). The action of this series of fibres is to bend both merion and cnemion. An 'extensor of the cnemion' is feebly developed.

"*Flexor propedis.*—The cavity of the cnemion is chiefly occupied by the penniform flexor (*f*) of the 'propes' (5), upon which it acts chiefly through the medium of the 'apodeme' (*e*), attached to the base of that joint.

"*Flexor dactyli.*—In like manner the penniform muscle, in the swollen basis of the 'propes,' draws, through the medium of the entapophysis (*g*), the 'dactylus' (6), powerfully, in contact with the claw-like process of the 'propes' (5).

"In the 'propes,' or fifth joint of the maxilliped, fasciculi of the muscular fibres are grouped to be inserted into the short basal apophyses of the lamelliform appendages (Pl. XXXIV, fig. 4, 6), which they tend to approximate, or to close upon or around the terminal chela (*ib.*, 7). These plates, which radiate from the end of the 'propes' like the petals of a flower, are expanded by being pressed against the mud or sand, and seem to require muscles only for closing them, so as to facilitate the withdrawal of the limb.

"The application of the maxillipeds in locomotion was observed by W. A. Lloyd, Esq., the constructor of the aquarium at Hamburgh, of which he was for some years the conservator, and subsequently the constructor of that at the Crystal Palace, of which aquarium he is now the manager.

"At Hamburgh, specimens of *Limuli* were kept alive from the year 1865 to 1870. From his observations of these Mr. Lloyd informs me, 'the ulterior pair of limbs' (maxillipeds, VII) 'are not employed for walking, but exclusively for burrowing. These limbs are terminated by four long, stiff, oval, or leaf-shaped lobes, jointed at their base to the leg, and capable of being opened and closed in a four-radiate manner. When it wishes to burrow these two limbs are sometimes alternately and sometimes simultaneously thrust backwards below the carapace quite beyond the hinder edge of the shell, and in the act of thrusting the lobes or plates on each leg encounter the sand, the resistance or pressure of which causes them to open and fill with sand, a load of which at every thrusting operation is pushed away from under the crab, and deposited outside the carapace. The four plates then close, and are withdrawn closed, previously to being opened and charged with another load of sand, and at the deposit of every load the

whole animal sinks deeper in its bed, till it is hidden all except the eyes. The great over-arching shield of the carapace again prevents one from seeing whether this excavating work is being aided by the fanning motion of the branchial false feet, but I *think* such a fanning is going on, as I have seen signs of sand being driven out as if urged by a current of water.

"Mr. Lloyd thus describes the use of the tail-spine in locomotion:—'The animal having climbed up a rock in the aquarium till it has got near the top of the tank (which in Hamburgh contained a depth of thirty inches of water), and having assumed a vertical position, it leaves go its hold on the rock and allows itself to fall back into the water; but its downward fall is instantly checked, and the creature propelled upwards by the powerful flapping of its false branchial feet, and when the impetus given by these appendages ceases the animal again sinks down, but is prevented from falling prone on the floor of the tank by alighting on the tip of its tail-spine. The moment this happens, and before the creature has lost its balance on the spine, the false feet make another flap and give another impulse upwards and forwards; all this time the position of the carapace is slanting, the top inclining downwards at an angle of about 45°, the hinder shell being at another angle, and the tail-spine hanging down vertically, and so it progresses by a combination of flapping and hopping till it reaches the limits of its tank and sinks to the ground. The *Limulus* was fond of thus going about at night, generally remaining on the sand all day.

"'Another use made of the tail-spine was as a lever by means of which it righted itself when it fell off a rock on its back. The spine is then bent, its point is planted in the sand so that it makes an acute angle with the carapace, which is then so far raised that some of the feet are enabled to grasp a projecting surface, and the crab then turns over.'

"The maxillipeds, no doubt, aid in burrowing, but the chief fossorial agent, as indicated by the size and disposition of the principal muscular masses, is the great 'cephaletral' digging shield.

"In an interesting paper by the Rev. S. Lockwood, he thus describes the American species:

"'The King-Crab delights in moderately deep water, say from two to six fathoms. Except in the case of the very young, which are probably carried hither and thither by the tidal flow, it never seeks the shallow water save for the purpose of reproduction.

"'It is emphatically a burrowing animal, living literally in the mud, into which it scoops or gouges its way with great facility by means of the anterior edge of its enormous cephalic shield. In the burrowing operation the forward edge of the anterior shield is pressed downwards and shoved forwards, the two shields being inflected, and the sharp point of the tail presenting the fulcrum as it pierces the mud, while underneath the feet are incessantly active scratching up and pushing out the earth on both sides. There is a singular economy of force in this excavating action, for the alternate doubling up or

inflecting, and straightening out of the two carapaces with the pushing-purchase exerted by the tail-spine, accomplish both digging and subterranean progression. Hence the King-Crab is worthy to be called the 'Marine Mole.'[1]

§ 2. "*Nervous System.*—The chief part of the neural axis is in the form of an elliptic ring girting the œsophagus. Of this ring three views are given, one from above (Pl. XXXVI, fig. 1, *a* B), one from below (Pl. XXXV, fig. 1, *a* β), and one from the side (Pl. XXXIV, fig. 1, *a* β); in order to show, besides the shape of the part itself, the precise position of the nerves arising therefrom or connected therewith. For the origin of a nerve is an important element in determining the homology of the part it supplies; and such determinations have weight, as will be seen, in wider questions, extending, in the case of *Limulus*, *e.g.*, even to class affinity.

"The part of the neural axis anterior to the œsophagus (Pls. XXXIV, XXXV, and XXXVI, *a*), and which, were the tube straightened and the mouth brought to its ordinary position at the forepart of the body, would be superior or dorsal in position, is an oblong mass, concave where applied to the tube (Pl. XXXVI), convex on the opposite side (Pl. XXXV), 3 lines in length and 4 lines in posterior or basal breadth, where its angles are continued into the side parts of the ring (Pl. XXXIV, fig. 1, β). There is no trace of lateral bipartition of the superœsophageal or cerebral part of the neural axis. The substance of the ring shows the same axial or longitudinal extent behind as before the œsophagus; viewed from below, as in Pl. XXXV, fig. 1, it seems to extend rather further before contracting to form the ganglionic chord. The narrowest parts of the ring are at the sides of the œsophagus; but this is transversely; vertically the substance there is equal to that of the hind part of the ring (Pl. XXXIV, fig 1, β). Two commissural bands unite the lateral parts of the ring Pl. XXXVI). The ganglions (Pls. XXXIV, and XXXV, δ, ε, ζ, *n*, θ) are confined to the thoracetral region.

"*Ocellar Nerve, n a.*—The first pair of nerves is the 'ocellar' (Pls. XXXIV, XXXV, and XXXVI, *n a*). They rise, with an interval of their own diameter, from the fore and upper part of the brain (Pl. XXXVI *a*), diverge with a gentle curve as they advance, bend round the front convexity of the stomach (Pl. XXXIV, fig. 1, *n a*), and ascend, converging to terminate each in its ocellus (*ib.*, *a*, 1). The length of the nerve is two inches.

"*Ocular Nerve, n* A.—The second pair of nerves is the 'ocular' (*ib.*, *n* A). Each nerve rises from a small conical process of the brain (Pl. XXXVI), where the special quality of an optic ganglion may be surmised to dwell. An interval of the basal breadth of the swelling divides the ocular from the ocellar nerve. The ocular nerve curves upwards, crosses the gizzard near the pylorus (Pl. XXXIV), then more abruptly bends outward (Pl. XXXVI), coasting round the apodeme (II) of the second limb, and retrograding obliquely to the compound eye, near which the nerve divides into a larger

[1] 'The "Horse-Foot Crab," '*Limulus polyphemus*,' by the Rev. S. Lockwood, Ph. D., the American Naturalist, vol. iv, 1870, p. 257.

dorsal and smaller ventral chord. The dorsal division (Pl. XXXV, fig. 2, *d*) soon expands, and resolves itself into a fasciculus of nervules, which subdivide, and finally supply or form the retinæ of the lenses at the upper and hinder part of the compound eye. The ventral, which is also the anterior division (*ib.*, *v*), is continued before expanding and resolving into the plexus which supplies the retinæ to the lenses at the lower and forepart of the compound eye.

"*Gastric Nerves.*—Two pairs of nerves arise posterior to the ocular pair. The nerves of the first pair (*n*, 3, Pl. XXXVI) pass forward, give filaments to the œsophagus and stomach, and are continued on into the hepatic and ovarian substance at the forepart of the carapace.

"*First Epimeral Nerve.*—The nerves of the second pair (on the outer side of the symbol *n*, 4, Pl. XXXVI) diverge, extend along the forepart of the anterior low and simple apodeme (II), subdivide, and are lost in the tissues of that part of the segment; answering, in position, to the epimerals [1] of the type segment. The term 'epimeral' will, accordingly, be given to this and the succeeding serially homologous nerves.

"*Second Epimeral Nerve.*—A somewhat larger nerve rises immediately behind the foregoing; the pair (Pl. XXXVI, *n*, 5) slightly diverge and ascend, when each second epimeral nerve bifurcates. One branch coasts along the anterior apodeme, the other inclines towards the interspace between that and the second more prominent apodeme, supplies muscular fibres thence arising, and gives off a recurrent filament (*n*, 6), traceable along the outer ends of the succeeding apodemes (II—VI, Pl. XXXVI), at a little distance from them, as far as the seventh epimeral nerve, where this begins to ramify.

"*Antennular Nerve.*—This nerve (*n* II, Pls. XXXIV and XXXV) rises from the under part of the base of the brain (*a*, fig. 1, Pl. XXXV), is rather larger than the second epimeral nerve, and supplies the first small forcipated pair of limbs, the homologue of the first, or inner pair of antennæ in higher and more differentiated Crustaceans.

"Two filamentary nerves rise from the interval between the antennular and antennal nerves at the beginning of the lateral parts of the ring (shown in Pl. XXXV).

"*Antennal Nerve.*—This nerve (*n*, III) is more than twice the size of the antennular one; it supplies the second limb (Pl. XXXV, III), which is sexually modified in the male of *Limulus polyphemus*. This limb, forcipated like the rest in the female, is the homologue of the outer and larger pair of antennæ in higher Crustaceans; and its origin is præ- or supra-œsophageal in *Limulus*.

"*Third Epimeral Nerve.*—From the dorsal aspect of the lateral part of the neural ring rises the third 'epimeral nerve' (*n*, 7, Pl. XXXVI). It runs forward and outward above the interspace between the second (*ib.*, II) and third (III) apodemes, and is resolved into a plexus of filaments beyond that interspace, which are lost in the glandular and other tissues of that region.

"*Mandibular Nerve.*—The third limb nerve (Pl. XXXV, *n*, IV), of the same size as

[1] Owen's 'Lectures on Invertebrata,' p. 298.

the second, comes off behind it, from the lateral part of the ring, β, and supplies the limb homologous with the 'mandible' (so called) in higher Crustaceans; which limb is marked IV in Pls. XXXIV and XXXV, where the nerve is traced through the coxal and basal joints.

"*Fourth Epimeral Nerve.*—From the dorsal aspect of the corresponding part of the neural ring is sent off the 'fourth epimeral nerve' (*n*, 8, Pl. XXXVI), having the same course and apodemal relations as the second and third of this series.

"*Premaxillary Nerve.*—This, with a more posterior origin than the mandibular nerve, repeats the characters of that nerve, in relation to the fourth limb, or homologue of the 'præmaxilla,' or first or anterior maxilla, in higher Crustaceans. The nerve (*n*, V) is shown in Pls. XXXIV and XXXV, entering and traversing the 'coxa' and 'basis' of the limb marked V. This limb is sexually modified in the male of *Limulus Molluccanus*, but not in the species here dissected.

"*Fifth Epimeral Nerve* (*n*, 9, Pl. XXXVI).—This repeats the relative position of origin to the premaxillary nerve which the antecedent one (*n*, 8) bears to the mandibular nerve, and holds the same relation in its course to the apodemes IV and V. It forms the plexus beneath that of the optic nerve, beyond which the filaments are lost in the tissues there. The optic nerve crosses dorsad of the first four epimeral nerves in its course to the compound eye.

"*Post-maxillary Nerve.*—The fifth limb-nerve (*n*, VI, Pls. XXXIV and XXXV), with a more posterior origin and a course more obliquely backward, repeats in limb VI the homologue of the post-maxilla or second maxilla, in higher Crustaceans the characters of the 'premaxillary nerve' in relation to limb V.

"*Sixth Epimeral Nerve* (*n*, 10, Pl. XXXVI).—This repeats the same relative position of origin to its answering limb-nerve as does *n*, 9; it is continued further obliquely backward before bending outward to its interapodemal space, and bifurcates before entering there, the hinder division descending to supply the strong adductor muscle of the sixth limb (VII in Pls. XXXIV and XXXV).

"*Maxillipedal Nerve* (*n*, VII, Pls. XXXIV and XXXV).—The nerve supplying that limb has its origin between the post-maxillary nerve and the beginning of the abdominal ganglionic chord, γ. It repeats the character of the antecedent limb-nerves in relation to its own articulated appendage, which is the homologue of the 'maxilliped' in higher Crustaceans.

"*Palpal Nerves.*—At the interspace between the origins of the post-maxillary and maxillipedal nerves, as in that between the latter and the ganglionic continuation of the neural centre, arise filaments which supply the spinigerous process or 'palp' of the compressed denticulate haunch-joint (Pl. XXXIV, figs. 2 and 5, *p*).

"*Chilarian Nerve* (Pl. XXXIV, fig. 1, *n**, and Pl. XXXV, fig. 1, *n**).—This rises between the origins of *n*, VII and *n*, VIII; it is appropriated to and richly ramified in the leaflike spinigerous appendage, articulated behind the base of the maxilliped, and

closing posteriorly the circumoral armature. The serial homology of the chilarian with the palpal nervules lends some countenance to that of the appendage, so supplied, being a detached spinigerous process or 'palpus' of VII."

[Referring elsewhere (at p. 464) to this pair of compressed spinigerous oblong plates, situated immediately behind the sixth pair of circumoral apppendages, and closing as it were the buccal orifice behind, Professor Owen observes "they recall to mind the pectinate appendages of the thoracetron in *Scorpio*. In *Limulus* they close or complete the oral armature posteriorly, forming the 'lèvre inférieure' of Cuvier, and a corresponding member of the 'trophi,' according to Savigny; but Latreille preferred to regard them as the haunches or jaw-lobes of the sixth pair of limbs detached. The haunch-joints, however, are present, though less dentated in the sixth pair of appendages (Pl. XXXIV, fig. 4, 1 *p*). The appendages in question have their own distinct pair of nerves (Pls. XXXIV and XXXV, fig. 1 *n**) arising between the origins of the main nerve of the limb (VII) and that of the ganglionic chord, suggestive of a serial homology with the palpal nervules. I am not," he adds, "however, satisfied with this as a ground for regarding the parts in question as detached limb-palps; and I therefore propose to call them '*chilaria*'" (from χειλάριον, a small lip).

Vander Hoeven refers to them as "the two pieces placed behind the sixth pair of feet, and which some authors consider as forming the lower lip."[1]

Huxley considers it "the rudimentary metastome," and, referring to the variation which the plate undergoes, mentions that "in *Calanus* it is excavated anteriorly by so deep and wide an emargination, that it almost appears to consist of two distinct lobes. In *Pontella*, on the contrary, the metastoma is a large flattened plate, whose terminal emargination, though wide, is not deep.[2]

I have invariably adhered to this view of the 'chilaria' in *Limulus*. Indeed, there seems no reason to doubt that this pair of oval oblong plates, the bases of which are united on the median line of the body, represents the inferior lip, and is homologous with the great conjoined but bilobed metastomatal plate placed precisely in the same position behind the mouth in *Eurypterus* and *Pterygotus*,[3] and I find that the researches of my distinguished friends, Dr. Anton Dohrn[4] and Dr. A. S. Packard, jun.,[5] into the

[1] J. vander Hoeven, 'Recherches sur l'Histoire Naturelle et l'Anatomie des Limules,' Leyden, 4to, 1838, p. 48, 7 plates.

[2] 'Medical Times and Gazette,' 1857, vol. xv, p. 188; 'Mem. Geol. Surv.,' Mon. I, 1859, "On the Anatomy and Affinities of the Genus *Pterygotus*," pp. 33 and 34.

[3] See 'British Assoc. Reports' for August, 1871, on "The Structure of Fossil Crustacea;" also 'Geol. Mag.,' 1871, vol. viii, p. 524. See also Parts I—IV of this Monograph.

[4] "Zur Embryologie und Morphologie des *Limulus Polyphemus*" ('Jenaischen Zeitschrift,' Bd. VI, Heft 4, 1871, p. 639.

[5] "On the Development of *Limulus Polyphemus*," 'Mem. Boston Soc. of Nat. Hist.,' 1870, vol. ii, p. 156.

development of *Limulus polyphemus*, have led them to adopt the same conclusions (see 'Development of *Limulus polyphemus*,' *infra*).—H. W.].

"*Seventh Epimeral Nerve* (*n*, 11, Pl. XXXVI).—This arises dorsad of the origin of the maxillipedal nerve, passes backward and outward to its proper apodeme (VI), where it divides, and, running onward, ramifies to supply the tissues in the hinder produced angles of the cephaletron.

"*Eighth Epimeral Nerve* (*n*, 12, Pl. XXXVI).—This is one of the same system of dorsal nerves, succeeding the seventh; it passes backward and slightly outward along the dorsal margin of the seventh apodeme (VII), and dips into the articular depressions between the cephaletron and thoracetron.

"*Opercular Nerve*.—The hindmost pair of cephaletral ventral nerves (*n*, Pl. XXXIV, and *n*, VIII, Pl. XXXV, fig. 1) is given off at or just before[1] the continuation of the neural ring into the 'ganglionic chord.' The nerves of this pair run along the sides of the latter for about 8 lines, then slightly diverge, curve outward, and send off one or two filaments laterally, before descending to penetrate the base of the anterior or opercular leaf-foot, or coalescent pair of limb-appendages of the segment anchylosed to the back of the cephaletron.

"The corresponding dorsal pair of nerves (*n* 13, Pl. XXXVI) also course along the sides of the ganglionic chord before diverging to ramify in the middle third of the interspace between the cephaletron and thoracetron.

"The ganglionic chord (γ, Pls. XXXIV and XXXV), extends backward about an inch before its first ganglion (δ) is formed; this is followed by three others (ε, ζ, η), and a terminal swelling (θ) situated about an inch and a half from the joint of the tail-spine. The interganglionic tracts average in length about $2\frac{1}{2}$ lines, slightly shortening as the chord recedes.

"Each of the four anterior ganglions gives off two pair of principal nerves, one dorsal and anterior (*n*, 14—17, Pl. XXXVI) the other ventral or posterior (*n*, IX—XII, Pls. XXXIV and XXXV), these terms not being absolute, but meaning the approximate relative position of the places of union of the nerves with the ganglion. The dorsal nerve is a serial repetition of the antecedent epimeral ones. It passes outward along the contiguous apodemal interspace, on emerging from which it divides; the posterior branch quickly subdivides; the anterior branch continues further before subdividing; all these filaments incline obliquely backwards before distributing themselves among the tissues of their corresponding abdominal segments. The dorsal nerves (*n*, 17, Pl. XXXVI) from the fourth ganglion run backward a short way before inclining outward. A_4^5 filament of each of the thoracetral epimeral nerves can be traced to the movable side-spine of its segment.

[1] "This lends countenance to the idea that the 'opercular limb,' viii, is the last of the cephaletral series." [See remarks on this plate in *Pterygotus, ante*, Part I, p. 40, *et seq.*—H. W.]

"The ventral nerve goes obliquely outward and backward to the space or joint between its own segment and the one in advance, penetrates the branchial leaf-limb at the part or moiety of its own side, distributes many filaments to the basal joint, and is continued on through the second and third joints, before being finally resolved in the fourth and terminal joint (Pl. XXXIV *n* IX—XII). More minute filaments are sent off; usually between the origins of the two chief nerves, from the four ganglions.

"The terminal ganglion (*θ*, Pls. XXXIV and XXXV) represents the coalescence of the nerve-centres of at least three segments. Its anterior dorsal pair of nerves (*n* 18, Pl. XXXVI) traverse the interval between the fifth (XII) and sixth (XIII) thoracetral apodemes, in a course more obliquely backward than the antecedent pairs. The corresponding anterior ventral nerve (*n* XIII, Pls. XXXIV and XXXV) supply the sixth pair of leaf-limbs or fifth branchial pair (XIII). Below the origin of this pair, nervous filaments (*r*, Pl. XXXIV) pass off to the lower fourth of the intestine.

"The second ventral pair (*n* XIV, ib.) is chiefly distributed to the fibres of the flexor muscles of the tail-spine, arising from and occupying the soft, rather tumid tract, which resembles a leaf-foot soldered down to form the covering of the hindmost part of the ventral surface of the thoracetron.

"The third pair of principal nerves from the terminal ganglion represents a bifid continuation of the neural axis (Pl. XXXV, *l*). After a course of about three lines each sends off a nerve (*n* XV, ib.) belonging to the ventral series, which supplies the hindmost or postanal region of the abdomen, affording the articular surface for the tail-spine.

"After sending off the above nerve, each continuation of the chord forms an oblong loop (ib., *k*), which, prior to the removal of the vascular sheath, looks like a ganglionic swelling;[1] beyond which the chord (λ, Pls. XXXIV and XXXV) continues along the side of the tail-joint, and, on entering the cavity of the tail-spine (c), resolves itself into a fasciculus of fine nerves (ib., *pl.*), resembling the 'cauda equina' of anthropotomy. But in this bundle a principal filament, or continuations of the chord (Pl. XXXIV, *μ*), can be traced about a third of the way down the spine. These nerves seem to constitute the major part of the tissues in the hollow of the spine, and render a marvellous supply of neurine to so hard, inflexible, and seemingly insensible a part.

"Each chord, λ, from the ganglionic loop sends off nine nerves, four directed towards the ventral (Pl. XXXV, fig. 1, *pl.*), four towards the dorsal (Pl. XXXIV, fig. 1, *a* 1—4) region of the spine: the ninth nerve, being of larger size, claims to be the continuation of the bifid neural axis. If the dorsal and ventral divisions be regarded as those of four nerves serially homologous with such divisions of antecedent primary pairs, they would indicate as many segments coalesced in the fore part of the spine. The ninth nerve and its divisions supply in a similar way the rest of the tail-spine.

* * * * * *

[1] As represented by Vander Hoeven, op. cit., pl. iii, fig. 2 *c*.

"Seeing the relations of these nerves as continuations of the neural axis, and the like relation of the artery of the spine to the dorsal vessel, I long ago (writes Prof. Owen) concluded the spine itself to be a continuation of the series of body segments, to be serially homologous therewith, and not with their 'appendages.' The coccygeal style of the Frog's endo-skeleton[1] is analogous to the tail-spine of the King-crab's exoskeleton. The antecedent part (*abdomen*, H. W.) wherewith the spine is articulated has no limbs. Is it also part of the '*pleon*'? (*abdomen*, H. W.), and does the post-ganglionic part of the neural axis indicate the extent of such part?"

[In an interesting conversation with the celebrated carcinologist Professor Henry Milne-Edwards in October, 1873, shortly after the publication of Professor Owen's Memoir from which I have so largely quoted, we discussed the question of the homologies of the tail-spine or 'telson' in *Limulus*, and he then frankly expressed his opinion that the nerve-structure described by Professor Owen as characterising the tail-spine of *Limulus* warranted the conclusion of that distinguished anatomist, and that it no doubt confirms his view that it represents the posterior segments of the rudimentary abdomen.

Although this conclusion differs from that expressed by many other writers, as well as by myself, who had considered the 'telson' or tail-spine as a median appendage and not a true segment (in which view its development at a later period in the life of the young King-crab seemed to lend confirmation), nevertheless I felt bound to reconsider the facts most carefully, and also to ascertain, if possible, whether there was any evidence which might be adduced from fossil forms bearing upon this question *pro* or *con*.

The evidence afforded by *Hemiaspis limuloides* (see Part IV of this Monograph, pp. 174—177, woodcut, fig. 64, and Pl. XXX, figs. 1 and 2) in favour of Prof. Owen's view of the telson in *Limulus* had not escaped the attention of that eminent observer.

At p. 176 I wrote as follows: In *Hemiaspis* "the abdomen consists of only three segments, each 2 lines in breadth and $1\frac{1}{2}$ line in depth. The first has no epimera, and appears to move freely at its articulation with the sixth thoracic segment. The second and third segments have small epimeral pieces, which are bilobed, with the posterior lobe more pointed. A line of small tubercles runs down the centre of these three joints, which are somewhat raised at their articular borders.

"The smallness of the abdomen, and its reduction from the assumed normal number of six segments to three, seems to indicate a form by which, with the help of others, we may bridge over the interval that has hitherto existed between these two groups, the *Eurypterida* and the *Xiphosura*" (see woodcut, fig. 72, p. 200).

In his Monograph on the anatomy of the American King-crab Prof. Owen writes (p. 500):

"Segments indicated by the nerve-pairs, but concealed or suppressed by the crust at the base of the tail-spine in *Limulus*, were realised in *Hemiaspis limuloïdes*, H. Woodw.

"The progress from the general to the special, from vegetative repetition to

[1] Owen, 'Anatomy of Vertebrates,' vol. i, p. 49, fig. 44 *c*.

concentrative unity, is exemplified in the living representative of the old form discovered by Salter in the bed of a Silurian sea now contributing to form the county of Shropshire (see woodcut of *Hemiaspis*, reproduced, fig. 72, p. 200).

"The ancestral 'pleon' (*abdomen*) has been almost 'rubbed out' in the thousandfold generations of which the Salem King-crab is the heir; but the palæozoic taint sticks to the nerve-element. Or shall we say that *Limulus*, made perfect for its sphere and habits of life, must have its 'alpen-stock' unbroken, of compact stuff without joints near the grasped end? But then the teleologist has to give an account of the intermediate or 'evolutionary transitional' condition of the three 'pleonal' (*abdominal*) segments manifest outwardly, as doubtless by their nerve-pairs and probably ganglion-centres within, but soldered together or 'anchylosed' in König's and Baily's *Bellinurus*." (Owen, op. cit., p. 501.)

By the kindness of Mr. Robert Etheridge, Jr., F.G.S., Acting Palæontologist on the Geological Survey of Scotland, I have received from him for examination a 'telson' or tail-spine of *Stylonurus*, discovered by James Powrie, Esq., F.G.S., of Reswallie, Forfarshire; in the grey micaceous, "Lower Old Red Sandstone" of the Sidlaw Hills, Forfarshire, which have already yielded to that ardent geologist such a grand series of Fish and Crustacean remains (see Parts I and IV of this Monograph, &c.).

Mr. Etheridge at once detected the importance of this specimen, and obtained permission of Prof. Geikie, F.R.S., the Director of the Geological Survey of Scotland, that it should be placed in my hands for examination and description. It is figured in the accompanying woodcut (Fig. 73, p. 200).

The specimen measures nearly seven inches in length, and is slightly injured at each extremity, which renders its original full length rather indeterminate, although from the curvature of the lateral borders it would seem to be nearly entire. Its greatest breadth is an inch and a half. The flat, central part is one inch in breadth. The borders are raised on each side, the centre being flat; but as we are looking at an intaglio impression of the fossil, the original, no doubt, had the centre raised and the borders bent downwards. In form it differs from *Stylonurus Scoticus*, being more elongated and straighter, and less spatulate in outline, agreeing better with *S. ensiformis*, H. W., from the same locality, and also collected by Mr. Powrie (see Part IV of this Monograph, Pl. XXI, fig. 5).

What renders this specimen of so much interest is the fact that it affords clear evidence of segmentation, the central part being divided by ten transverse lines, which extend from side to side, but do not cross the raised lateral border (save in the case of the sixth and seventh from the proximal end, which slightly indent it). The border of the telson is finely serrated on either side, but no scale-markings are visible.

This specimen appears to lend important weight to Professor Owen's conclusion as to the compound nature of the "telson" in *Limulus polyphemus*, and I have therefore felt that its introduction here would prove both opportune and appropriate.

The evidence of concealed segments afforded by the dichotomising nerve-fibres of the abdomen and 'telson' in recent *Limulus* under dissection (see Pls. XXXIV, XXXV,

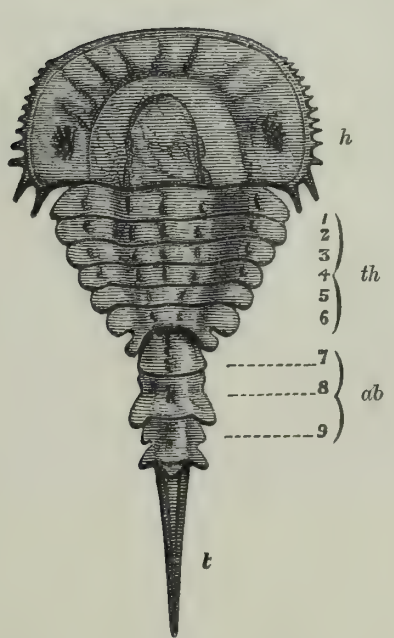


Fig. 72.—*Hemiaspis limuloides*, H. Woodward, Lower Ludlow, Leintwardine.

h, the head; *th*, the sixth thoracic segments; *ab*, the three abdominal somites; *t*, the telson.

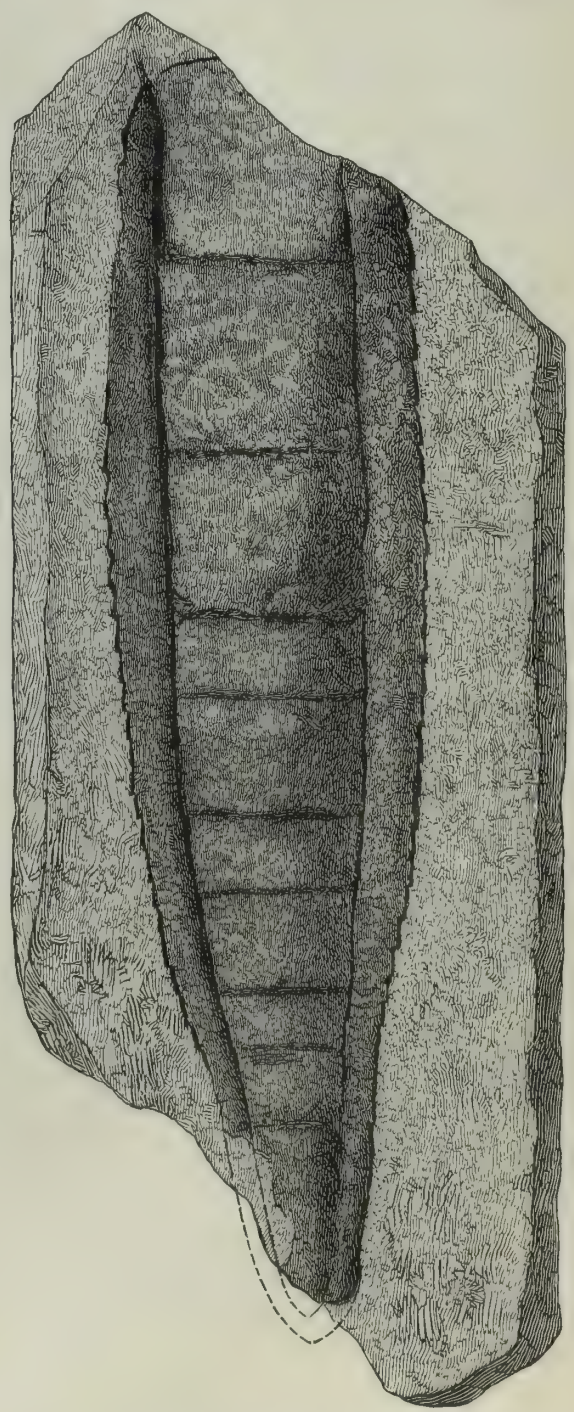


Fig. 73.—Tail-spine of *Stylonurus*, sp. (natural size), Lower Old Red Sandstone, Forfarshire. Drawn from a specimen in the Museum of the Geological Survey of Scotland.

and XXXVI) is here confirmed by traces of external persistent segmentation in the 'telson' of an ancestral type, dating back to the "Lower Old Red" period.—H.W.]

§ 3. *Digestive System.*—"This system of organs includes a 'mouth,' with instruments for seizing and comminuting the food, a 'gullet,' a 'stomach,' an 'intestine,' with vent and accessory glands, of which, in the present genus, the 'liver' only has been recognised.

"The mouth is median, and situated, as in other masticating Crustacea, on the under surface of the body; it is, as in them, surrounded by modified portions of articulate limbs, working laterally, but resembles that in Spiders in respect of its distance behind the fore border of the cephaletron (Pl. XXXIV, fig. 2). The circumoral integument is yielding and elastic, cushioned out with soft tissues, including fibres, interlacing, and susceptible, if muscular, of giving change of form and position to the thick and prominent lips, endowing them with movements, small in extent, but various, for seizing the morsels of food torn by the haunch-palps or 'carders' (ib., *p*, *p*). The thick labial epithelium yields to such movements by transverse folds or indents. The mouth opens on a plane not only behind that of a basal attachment of the antennules (or 'first pair of chelate appendages,' ii), but also clearly behind that of the basal attachments of the 'second pair' or antennæ (iii). Nor can those of the 'third' pair be said to be placed 'posterior to the mouth.' Their nerves arise rather in advance than behind the œsophageal tube; and their haunches are on the transverse parallel of the anterior lip, as shown in Pl. XXXIV, fig. 1, *n* IV, and fig. 2, *p* IV. In a general way the mouth of *Limulus* may be said to occupy the interspaces of the haunches (*coxæ*) of the right and left limbs, iii—vii, these limbs being crowded or close-packed at their basal articulations on each side of the mouth, whence they diverge to their pincer-shaped tips. The haunches are compressed as if squeezed together, and their under or median borders are produced with a convex margin, which, with more or less of the contiguous, flattened surface, is beset with sharp, short, slightly curved spines. These are not mere processes of the chitine, but are slightly moveable, their base being articulated to a pit. The spiny plate, or 'palp,' of the first of these jaw-feet (iii) is inclined backward, and overlaps part of that of the second (iv), which has a like relation to the third (v); this is set more transversely, and is wedged, as it were, between the second and fourth. The haunch of this foot (vi) has a similar position between that of the third (v) and the somewhat less spiny haunch of the last pair of legs or 'maxillipeds' (vii). This complete series or circle of carding instruments is bounded in front by the three-jointed antennæ (ii), having the same chelate structure as in the multiarticulate ones of *Pterygotus;* it is closed behind by the 'chilaria' or pair of appendages" marked * in Pls. XXXIV and XXXV.

"The operation of these circumoral instruments in the living King-crab is thus described by the Rev. Samuel Lockwood, Ph.D., a close and accurate observer of its habits (see the 'American Naturalist,' vol. iv, p. 260):

"'The food is held immediately under the mouth by the claws or nippers of the anterior pair of jawless feet (antennules), aided if necessary, by some of the others. The basal joints or manducatory haunches then begin an alternating motion of these members upon food by drawing one of the spiny or rasp-like joints against the opposite one of the same pair, the food, of course, being between the two. This chewing by means of these opposing rasps reminded me of the hand-carding process, in which the card held by the right hand is brought towards and against the one held in the left hand, the wool being between; then the right hand card is held still, and the left hand duplicates the motion, and so on. The fine particles rasped off by the incurved teeth pass into the mouth.'

"The tumid and wrinkled margins of the mouth quickly contract to an œsophagus about a line in diameter. This tube (Pl. XXXIV, fig. 2 *œ*) curves upward and forward in a course of $1\frac{1}{4}$ inch, then dilates into a conical proventricular cavity (*r*) extending downward, about 5 lines in depth by $3\frac{1}{2}$ in breadth at the base. From the fore part of the base a second short canal ascends, to terminate by a slight vascular prominence in the stomach (*s*). The epithelium, or modified chitine, continued from the mouth along the gullet and proventricular, becomes suddenly thickened in the stomach, and is disposed in numerous transverse ridges. The muscular coat of the stomach is concomitantly strengthened, attaining at one part a thickness of 3 lines. The pyloric end (*mt*) projects as a truncated cone, 4 or 5 lines long, into the dilated beginning of the intestine (*i*). The truncated apex of the pyloric cone is slightly tumid. The epithelium lining that part has resumed its thinness and subtransparency.

"The intestinal tunics appear to be reflected from the base of the pyloric cone; they define a dilated beginning of the canal, and gain a slight thickness of the muscular coat as they contract to the common size of the intestinal tube, the area of which is about 5 lines in transverse and 3 lines in vertical diameter. The tube goes nearly straight to the vent (Pl. XXXIV, fig. 1 *i, v*), but, about half way there, it contracts transversely, and exchanges its oval for a circular section, with a diameter of $2\frac{1}{2}$ lines. Near the vent it again expands, chiefly transversely, and the muscular coat there gains somewhat in thickness. The vent (Pl. XXXIV, fig. 1 *v*) is a transverse slit with tumid margins, just anterior to the joint between the thoracetron and pleon.

"The contents of the alimentary canal were pulpy and scanty. The principal food of the *Limulus polyphemus* is stated by Dr. Lockwood (*loc. cit.*) to be Nereids, routed by the cephaletral limbs out of the mud or sand displaced in the act of burrowing.

"The only gland in communication with this canal is the liver. It is of great size; its minute terminal acini are compactly massed together, and occupy most of the space in the cephaletron not given to other organs, mainly the generative, the ramifications of which interlace with the hepatic lobes. This mass extends forward to the space anterior to the stomach, and backward by a narrow tract on each side of the intestine in the 'thoracetron.' The lobes, or larger groups of acini, form a close-packed series on each

side, corresponding in the main in number with the apodemal spaces and the epimeral nerves. The least unsuccessful trials of injecting the terminal canals and acini indicated the greater transverse and less longitudinal extent of the hepatic lobes or primary divisions of the gland. The gathering tubes of the initial or acinal ducts of these lobes course, in the main, transversely towards the intestine until they quit the lobe, when they converge abruptly to form the terminal duct. The anterior of these receives the tributary ducts of the four chief anterior divisions of the liver; the posterior terminal duct is formed by the union of the same number. The ducts of two or three of the anterior lobes unite to form that which enters the main or terminal anterior duct; those from the four posterior lobes, unite and enter the posterior terminal duct by two canals. The arrangement, however, may be varied in other specimens. But the principle of segmental constitution as here exemplified will be found, I doubt not, in all *Limuli*. It indicates the liver to have been developed in relation to the primitive composition of the cephaletron, of seven or more antero-posteriorly succeeding segments, and that there was a pair of livers or hepatic lobes to each. It interestingly exemplifies the way of subsequent concentrative growth characteristic of the mature and procreative individual.

"The bile is conducted to the intestines by two terminal ducts on each side; the first pair (fig. 2, Pl. XXXIV *l*) open upon the sides of the beginning of the tube, where it contracts to the ordinary calibre; the second pair (ib., *m*) open about 9 lines beyond, and nearer the dorsal part of the intestine.

"As in the King-crabs, certain Spiders (*Epeïra*, e. g.) have their ventral mouth provided anteriorly with a chitinous plate, 'labrum' or 'prostome,' and posteriorly with a 'labium' or 'metastome' which is soldered to the cephaletral plastron, not bifid and movable as in *Limulus* (Pls. XXXIV, and XXXV, fig. 1, *). The œsophagus rises, at first, vertically dorsad, then bends back at a right angle, traversing in that part of its course the neural ring before expanding into the stomach. This cavity is, in most Spiders, produced into cæcal appendages, which, in some, extend into the basal joint of the cephalateral limbs. The bile-ducts open into that part of the intestine which traverses the thoracetron ('abdomen' of arachnologists). The proportion of difference to resemblance must be kept in mind when speculating on the degree of affinity of Xiphosura to Arachnida."

§ 4. "*Sanguiferous System*.—The dissection of *Limulus* was commenced from that aspect or plane of the body next to which, in Invertebrates, is the part of the neural axis called 'supercesophageal,' and which, as it supplies nerves to the organs of sense, answers to the brain in Fishes. As in these Vertebrates also, the removal of the neural or dorsal part of the skeleton exposes the vascular system analogous to the so-called 'aorta' of Fishes, and homologous with the 'dorsal vessel' in Insects. In *Limulus* the walls of this vasiform heart exhibit muscular and valvular structures, for the same purpose or office as those of the vertebrate 'heart.'

"In a specimen dissected, with a carapace, or upper crust of the two chief parts of

the body, 9 inches in length, the heart was 4 inches 8 lines in length. It was included in a delicate membranous sac analogous to a pericardium, but forming, in fact, the wall of a venous sinus. This wall consists of two layers. One may be properly termed a 'tunic;' it includes extremely delicate fibres, chiefly transverse, but reticularly interwoven in a fine cellular bed, the inner surface of which has been the seat of formifaction, or vital crystallisation, of particles from the contained fluid, forming an epithelium,[1] the whole resembling a fine arachnoid membrane. The heart is fusiform, widest at its hinder third, gradually narrowing, transversely, to its fore end, which is $2\frac{1}{2}$ inches from the fore part of the cephaletron, more rapidly contracting to its hind end, which is $1\frac{1}{2}$ inch from the joint of the tail-spine. In the vertical diameter (Pl. XXXIV, fig. 1, *r*, *r*) the hinder contraction is more gradual.

"The heart-wall consisted of an outer, thin, smooth, compact coat, and a wall of striate muscular fibres consisting of a thin outer longitudinal layer, and a thicker transverse or circular series. The wider part of the heart shows traces of an epithelial lining due to the action initiated or invited by a surface in contact with the formifying material in solution. The arachnoid coat of the pericardial sinus is reflected over the outermost proper tunic of the heart, and is continued into the venous ostia where it gains thickness.

"These ostia are sixteen in number, arranged in seven pairs at the sides, but towards the dorsal surface, of the heart, with a terminal eighth pair. The hinder 'ostia' are rather nearer together than the others. The muscular tunic in the intervals of the ostia (Pl. XXXIV, fig. 1 *r*, *r*) is about a line in thickness, but thins off rapidly at the two ends of the heart. Each 'ostium' (ib., *o*, *o*) is provided with a pair of narrow semilunar valves, placed with the intermediate slit almost transversely to the axis of the cardiac tube.

"The foremost artery runs to the 'ocelli,' is there connected with, or seems to enclose, the nerve; it then bends down, following the curve of the carapace to the angle formed by the upper with the flat under surface of the digging shield, near which angle the artery is reflected backward and cannot be further traced as a distinct tube. On each side of the origin of the 'ocellar' artery arises one of double the size, which, diverging from its fellow, curves outward and downward over the fore-part of the intestinal canal (Pl. XXXIV, fig. 1, *s*); it gives off, in this course, a branch which ramifies upon the gizzard, a second to the intestine and liver, the main trunk being continued to the nervous annular centre (ib., β), where it expands, and combines with its fellow of the opposite side to form a sheath for that centre analogous to a 'dura mater.' This rather loose sheath is continued along the ganglionic ventral chord, and is prolonged, like a loose neurilemma, upon the nerves sent off therefrom, as it is upon those in connection with the annular centre.

"Fine size-injection being thrown into the 'heart' from behind forward appeared to

[1] Owen, 'Anat. of Vertebrates,' vol. iii, p. 499.

give a rich display of arterial ramifications. But dissection showed that the contents of the seeming arteries ceased to be the simple injected matter where the 'gastric arches' (ib., *s*) reached the nervous ring (ib., β); for here the coats of the artery become thinned, the injection lining them as a thin flake of colouring matter, and, at the same time, covering a thinner membrane which formed the 'neurilemma' or chief layer of the delicate tunics of the nervous matter of the neural ring.[1] The same condition was presented by the seeming abdominal arterial trunk continued backward from the neur-arterial circle (Pl. XXXVI, *a*, B, to or of nerve *n* 19). On slitting open the coats of the blood-vessel and washing out the flake of injection, the ganglionic nervous chord was exposed in its interior.[2] The same result followed the like perquisition of the smaller ramifications of the vascular system into which the injection had penetrated, and engendered the conviction that the main pair of arteries had but a brief course as such,[3] becoming resolved on reaching the neural ring into blood-sinuses, a condition which prevails throughout a great proportion of the vascular system of *Limulus*. The whole nervous system, save where the terminal twigs are lost in the tissues, is bathed in the blood of these sinuses, which retain the appearance of ramified vessels, through their relations to the nerves as the vascular envelopes of these.[4] Elsewhere the sinuses expand, lose the character of tubes, or vessels, occupy the interspaces of viscera and muscles, initiate the ramified branchial system of vessels, and finally return the blood to the pericardial-like sinus enclosing the heart.

"A pair of arteries is sent off near the anterior pair of ostia, and are closely connected with the much larger veins emptying the neighbouring sinus into the corresponding parts of the pericardial one. These arteries pass outward and forward, and subdivide into branches, which are lost upon the epimeral nerves. I was unable to distinguish an artery

[1] "Preparation No. 1303 c, Physiol. Series, Mus. Coll. of Surgeons."

[2] "The neurine thus seems to be small in proportion to the thick neurilemma, as Gegenbaur remarks, but he did not recognise the share taken by the arterial tissues in this sheath :—'Bezüglich des feineren Baues soll die schon oben angeführte dicke Umhüllung des Schlundringes erwähnt werden, derzufolge der eigentliche Nerventheil des Schlundringes relativ klein erscheint,' op. cit., p. 241."

[3] "They are shown as cut off from the arches and lost upon the brain in Pl. XXXVI."

[4] "This interesting stage in the differentiation of nerves and vessels was demonstrated in my Hunterian lectures of 1852, 'Organisation of the Entomostraca illustrated in the Limulus,' Lecture XVI, *Crustacea*, 'Synopsis,' March, 1852, and is briefly enunciated in the volume on INVERTEBRATA as follows: —'The sides of the great œsophageal ring are united by two transverse commissural bands; but the most remarkable feature of the nervous axis of this Crustacean is its envelopment by an arterial trunk. A pair of aortæ from the fore part of the heart arch over each side of the stomach, and seem to terminate by intimately blending with the sides of the œsophageal nervous ring. They, in fact, expand upon and seem to form its neurilemma; a fine injection thrown into them coats the whole central mass of the nervous system with its red colour,' 'Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals,' by Prof. Owen, F.R.S. (2nd edit., London, 1855, Lecture XVI, p. 310). Gegenbaur, in his historical treatise on *Limulus* (op. cit., p. 241), remarks:—'Auch die peripherischen Nerven sind sämmtlich von einer dicken Hülle umgeben, die sogar noch makroskopisch erkennbar ist.'"

corresponding with the second osteal vein. This vein courses outward near the hind border of the cephaletron, bends forward, and runs parallel with the lateral or ocular ridge as far as the compound eye: its branches are short, and speedily expand into sinuses.[1] A pair of arteries are obscurely indicated arising near the last pair of 'ostia,' passing obliquely outward and backward. The posterior or pleonic artery (Pl. XXXIV, fig. 1 *t*) has more definite tunics and holds a longer course than those from the fore-part and sides of the heart. It is wavy at its beginning, in relation to the varying directions of the tail-spine, in its flexile movements upon the body. The artery having entered the body of the spine continues its course as such, along the dorsal side of the cavity, through two thirds of its length, then subdivides and blends with the sinuses continued from the ventral chord and investing the 'cauda equina' of the tail-spine.

"The veins or venous sinuses with the least indefinite form are those that course along beneath the medilateral ridges of the cephaletron in association with the arteries, and those which follow and lie near the margins of both cephaletra and thoracetra. The latter return their blood by the posterior veins, united by the median channel with the pair in advance, their common trunk opening into the hind part of the pericardial sinus.

§ 5.—"*Respiratory System.*—The gills consist of thin membranous plates of a broad semi-oval shape; there are from 150 to 200 in each gill or group, the number diminishing in the hinder ones. The gills are in pairs, attached to the upper, hinder, or inner surface of the proximal joints or broad coalesced plates of the last five thoracetral limbs (IX—XIII, Pls. XXXIV and XXXV).

"The branchial plates overlap each other from before backward. The anterior and exterior one is the smallest; the others progressively increase to a little beyond the

[1] That an arterial canal accompanies the vein is indicated by the course of the blood, as observed by Packard in a living larva of *Limulus*:—"I could not see the walls of any of the arteries; and, indeed, the arterial blood seemed to flow in channels exactly like the venous sinuses, as in the arteries which pass around the margin of the carapace the blood-disks were seen to pass by irregular currents towards the front edge of the margin. The anterior aorta could not be detected in the young *Limulus;* but on each side of the end of the heart the blood could be seen rushing out and in, and with a general course downwards beneath the œsophagus, while a current of blood flowed on each side of the stomach and œsophagus, and thence went out at a considerable angle to the edge of the carapace, where it divided, sending a branch under the ocelli, and another along the outer edge of the cephalic shield, and again subdivided opposite the second pair of cardiac valves, one current following the edge of the cephalo-thorax and the other going going on towards the heart. The abdominal arteries represented by powerful currents of blood issuing from between the last two pairs of cardiac valves are directed obliquely outwards and backwards. The caudal aorta sends a current nearly to the tip of the spine, the venous sinuses returning it along the sides. The simple arrows mark the course of the returning currents, which flow from all parts of the body towards the valves. 'Development of *Limulus polyphemus*,' pl. v, fig. 27, p. 171." This admirable memoir appeared subsequently to the reading of Prof. Owen's paper before the Linnean Society, and the report given of it in the number of 'Nature' for January 25th, 1872, is quoted by Dr. Packard at p. 201. Dr. Packard notes that the heart "beats ninety times a minute" in the larva after the first moult.

middle of the series; the hindmost again diminished, but in a less degree; the whole mass has the full oblong or irregular oval form shown in fig. 2, Pl. XXXVI. Each plate is strengthened by a chitinous filament along its free border, thickest where this is exposed, so that the length of the gill is greater at its free or floating side than along its attached base: the free margin is also ciliate.

"Each gill-plate consists or two layers or membranes, united along the chitinous border, and also by numerous filaments, so far apart as to divide the interspace into reticular canals or cells, smallest at a subcentral space (fig. 3 *a*), and affecting a concentric arrangement as they approach the free borders of the gill-plate. The two constituent layers of the branchial plate may be regarded as productions or duplicatures of the delicate skin of the upper or inner surface of the lamelliform limb.

"From a venous sinus along the base of attachment of the gill-plates[1] the blood passes freely into the interlamellar spaces, whence it enters the vessels coursing along the border of each plate, from the inner side, where the vessel is largest, towards the outer side (Pl. XXXVI, fig. 2 *a*). Here appears to begin the returning system of branchial veins on the fore part of the base of attachment. These veins ascend and converge on each side of the intestine, and traverse the pericardial sinus to enter directly the heart by the five pairs of ostia at the widest posterior part of that organ.

"The muscles which divaricate the branchigerous limbs, and at the same time separate the gill-plates and expand their cavities to the extent permitted by the interposed columns, act as inspiratory ones, inviting the flow of blood from the abdominal sinuses into the cavities of the gill-plates. This action may be supposed to take place when the King-crab is moving or resting in its atmosphere of sea-water. The muscles which approximate the branchigerous plates and press them against each other and the thoracetron will close the ciliate slits leading to the gills, will compress those organs, and tend to squeeze the blood from the reticulate interspace of their constituent lamellæ. Such movement must be 'expiratory' and also effective in defending the delicate surfaces of the branchial membranes from the atmosphere of muddy or sandy sea-water when the King-crab is burrowing either for food or concealment.

§ 6.—"*Generative System.*—In *Limulus* the sexes are distinct;[2] the male is smaller than the female, and in both the generative organs lack those accessory parts that relate to intromission in some higher Crustaceans.

"The ovarium is a system of ramified tubes and cavities, occupying chiefly the dorsal region of the body; it extends along the median part of the thoracetron, and expands

[1] "'Il paraît exister une libre communication entre ces diverses poches respiratoires; car, en introduisant de l'air dans une de ces duplicatures on voit non seulement s'écarter les lames de la même branchie, mais même se gonfler toutes les branchies, ainsi que l'espace membraneux entre les pattes abdominales,' J. van der Hoeven, op. cit., p. 19. The intercommunicating passage is the basal sinus, related to the gills, physiologically, as a 'branchial artery.'"

[2] [The separation of the sexes characterises the Crustacea generally, save in the aberrant Cirripedia, in which the greater part appear to be hermaphrodites.]

laterally in the cephaletron. Parts of the ovary are single and median, the rest consists of parial, symmetrical, lateral, ramified tubes, chiefly situated in the cephaletron.

"The hindermost cavity (Pl. XXXV, fig. 6 *q*) is a longitudinal tube, commencing by a blind end above the rectum; it extends forward, expands, and bifurcates about the middle of the thoracetron; the branches at first diverge, then bend inwards and reunite, sending back into the interspace of the bifurcation a short blind sac. From the base of this heart-shaped portion the bifurcate tubes are continued forward, slightly diverging, leaving a mid-space for the heart and intestine, as they cross the articulation between the thoracetron and the cephaletron. About two inches in advance of the second bifurcation each tube expands laterally into a triangular cavity, from the outer and fore angles of which the ramified systems of the lateral loops, q'', are continued. A small branch is sent off from the outer side of the dilatation. Three or four tubes converge from its fore part, and anastomose[1] to form the anterior single symmetrical cavity, $q^{\times}$. This is oblong, subquadrate, subdepressed, and subreticulate. It is longitudinally channelled above by the fore part of the heart resting thereupon, this part of the ovary being interposed between the heart and intestines (Pl. XXXIV, figs. 1 and 2 *q*). It seems to have been developed in or from the last remnant of the including germ-mass. From the hinder and outer angles of the antero-median part of the ovary proceeds the tube, which passes outward and backward, joins that from the fore part of the lateral expansion, and curves outward and forward to meet and inosculate with a similar retrograde branch from the fore and outer angle of the antero-median lobe. From the outer side of these ovarian loops (Pl. XXXV, fig. 6 q'') proceed four or five branches, which interramify with the hepatic lobe. The branch tubes ($q^{\times}$) continue from the fore part of the antero-median sac, and its loops are continued, subdividing and reticularly anastomosing, along the sides of the gizzard to the fore part of the cephaletron.

"Each of the main parial oviductal canals, before converging to the anterior reunion, dilates and sends outward and backward a wide tube, which, after sending off, or rather receiving, three large tubes ($q^{\times\times}$), is continued backward as the common oviduct (Pl. XXXV, fig. 6 *o*, *o*). The hindermost of the three large tubes passes outward and backward to near the outer ends of the joint between the cephaletron and thoracetron, and there curves forward beneath the lateral cephaletral ridge, and receives the ova from the part of the ovary extending to the lateral margin of the cephaletral cavity. The foremost of the three branches collects the ova from the deeper seated interapodemal parts of the ovarium, the intermediate branch those from the dorsal level above and exterior to the apodemata.

[1] "'Lectures on Invertebrata,' ed. 1855, p. 329, shown in *Maia*, in figs. 135, *a'*, *b'*. Anastomoses between the right and left system of ovarian tubes were noticed by Gegenbaur (loc. cit., p. 247), who well remarks on this evidence of crustacean affinity:—'Durch diese Verbindung beider Ovarialhälften reiht sich *Limulus* an viele andere Krustenthiere an, wogleichfals ein unpaarer Abschnitt der inneren Genitalorgane vorhanden ist.'"

"The numerical correspondence of the lateral tributaries to the main median or submedian receptacles of the ova with the neural indications of the segmental constitution of the two chief divisions of the body is less obvious than in those of the hepatic masses. This may be due to the later period of development of the genital factories.

"The part of the ramified ovarian system to which the term oviduct is here applied is the tube, *o*, continued from the common stem of the three last-described tubes, and passing backward, inward and downward, across the cephalo-thoracetral joint to the part of the upper or inner surface of the 'opercular' limb, viii, shown in fig. 6, Pl. XXXV. The termination here of the oviduct (*p*) was rather prominent; the outlet is transverse, and formed by tumid labia, with the inner surface transversely plicate.

"The bifurcation of the hind part of the ovary, before passing from the thoracetron to the cephaletron, relates mechanically to the accommodation of the cardiac and intestinal tubes during the frequent and forcible inflections of the two great body-chambers upon each other. The laden ovarium, instead of being pressed down upon the heart (as it would have been if it had been continued as a single median and vertically parallel viscus across the joint where the cephaletron was depressed at an angle with the thoracetron), slips, by its division, on each side of the heart during the inflection. A similar relation to convenience of package governs the forward extension of the ovarian bipartition in relation to the main parts of the heart and intestine.

"The most significant difference between the female organs of *Limulus*, and those of the higher or malacostracous, squat-eyed Crustaceans is the absence of the dilated part of the oviduct forming the copulatory pouch, or 'spermatheca,' which absence relates to there being no intromission in the act of impregnation in *Limulus*.

"In the male, the testes are ramified and subreticulate, like the ovaria, and occupy almost an equal extent of the two great cavities of the body. The sperm-ducts open upon a corresponding position of the opercular plate (Pl. XXXV, fig. 8 *p*), their termination being on a smaller but rather more prominent cone of thin yellow chitine, at the apex of which the sperm-tube terminates by a whitish bilabiate orifice (Pl. XXXV, fig. 7 *b*)."[1]

Whilst giving the foregoing description of the anatomy of *Limulus polyphemus* from the pen of Professor Owen,[2] we must not omit to record that, as early as 1838, Professor

[1] Dr. Packard describes the spermatozoa as having a broad oval body, sometimes contracted before the anterior end, and posteriorly suddenly terminating in a filament about four times as long as the body. "On the Development of the *Limulus polyphemus*," 4to., 'Mem. Boston Soc. Nat. Hist.,' vol. ii, p. 156.

[2] 'Trans. Linn. Soc.,' 1873, vol. xxviii, pp. 459—506 (read December 21st, 1871, and January 18th, 1872). See also Owen's 'Lectures on the Comparative Anatomy of Invertebrata,' 1st edit., p. 181, 1843, and 2nd edit., pp. 319, 320, 1853.

J. Vander Hoeven had contributed a valuable memoir[1] on the sole other surviving representative of the XIPHOSURA, the *Limulus Moluccanus*.

An excellent account of the general anatomy of *Limulus polyphemus* will also be found in Professor Huxley's lectures on the Invertebrata[2] (1857). Professor Gegenbaur's researches on the anatomy of *Limulus* appeared a little later in 1858.[3]

The liberality of the French Government in publishing the results of researches carried out by the scientific expedition to Mexico in 1867 (although much delayed by the siege of Paris), enabled Professor Alphonse Milne-Edwards to produce in 1873[4] a monograph on the anatomy of *Limulus polyphemus* most admirably illustrated by twelve folio chromo-lithographic plates, which for colour and excellence leave little to be desired. We shall make further references to these memoirs as we proceed.

EXUVIATION AND REPLACEMENT OF LOST APPENDAGES.

We are indebted to the Rev. S. Lockwood, Ph.D., for a series of most valuable observations on the American "Horse-foot Crab," *Limulus polyphemus*, Latr., carried on at Rariton Bay, New Jersey, U. S. A.[5]

According to Dr. Lockwood, the exuviation of the King-crab is performed several times during the first year of its life, and at very short intervals, varying according to the time of hatching. Dr. Lockwood believes that the young Limuli which are hatched in the latter part of June will complete five or six moults before the winter sets in. Even in the case of the adult King-crab he thinks it probable that the shell is cast more than once in the year. He mentions the capture of an adult female *Limulus* in the Oyster Dredge, during a fine open February, in Rariton Bay, which had just shed its shell and was still quite soft. Like all other Crustacea it moults more frequently during the earlier and more rapid period of growth than afterwards.

Limulus being a great burrower he not unfrequently disturbs the bivalve Mollusca in their submarine retreats. Dr. Lockwood mentions an instance of a *Limulus* which had either accidentally trodden upon or had wilfully seized the projecting siphons of a

[1] 'Recherches sur l'Histoire Naturelle et l'Anatomie des Limules,' 1838, Leyden, 4to, pp. 48, 7 plates.

[2] "Report of Lectures delivered at the Royal School of Mines," 'Medical Times and Gazette,' 1857, vol. xv, p. 188. See also his recently published volume, 'A Manual of the Anatomy of Invertebrated Animals,' small 8vo, London, 1877, pp. 700.

[3] Gegenbaur, "Anatomische Untersuchung eines Limulus, mit besonderer Berüksichtigung der Gewebe" ('Abhandl. d. Naturf. Gessellsh. zu Halle,' Bd. 4, Hefte 2 u. 3, 1858, p. 227).

[4] 'Études sur les Xiphosures et les Crustacés de la Région Mexicaine,' cinquième partie, Paris, folio (1873), pp. 44, 12 coloured plates.

[5] Communicated in October, 1869, to the 'New York Lyceum of Natural History,' and subsequently printed in July, 1870, in 'The American Naturalist,' vol. iv, No. 5, p. 257.

Venus mercenaria; the siphons were instantly withdrawn, and the less agile King-crab found himself next moment a prisoner with his limb nipped firmly between the valves of the outraged *Venus*. But here an important difference is noticeable between *Limulus* and an ordinary Crab or Lobster; had either of these been thus trapped by the leg, they would have speedily made good their escape by giving their body a violent jerk and leaving the imprisoned limb behind them, a cicatrix forming over the articulation for the lost limb, which after three or four moults would not only have been reproduced, but would have regained its normal size. It must, however, be borne in mind that the leg of a Decapod is not homologous with that of *Limulus*, whose organs of locomotion are modified palpi or maxillipeds rather than true feet, all its walking-appendages being mouth-organs at their proximal end, which would render their replacement in *Limulus* as difficult as would be that of the maxillæ or maxillipeds in a Decapod Crustacean, of the separate reparation of which we have no recorded instances.

The periodic exuviation of *Limulus* seems to be a very simple and expeditious process. "A thin narrow rim runs round the under side of the anterior portion of the cephalic shield. This is in fact the widest part of the animal. Just before the time for exuviating a separation occurs between this rim and the perimeter of the anterior shield. To the unaided eye this rent is altogether imperceptible, but it splits open on the exertions of the animal; and at this opening it emerges from its old shell. As the opening is in front and in the place of greatest width, and moreover as the shell is subcoriaceous and somewhat yielding, and at this particular place is very thin, *Limulus* enjoys in this respect a great advantage over the higher Crustacea, whose moult takes place by a separation between the posterior border of the carapace and the abdomen, and whose shell is composed of more unyielding materials.[1]

"The exuviation of the King-crab takes place several times during the first year, and at very short intervals. How many I do not know, as that must vary according to the time of hatching. But I think," says Dr. Lockwood, "the young produced in the latter part of June will accomplish five or six moults before the cold weather comes" (op. cit., p. 261).

The same author records the exuviation of a large female *Limulus*, which measured eight inches in the shorter diameter of its cephalic shield, but which after moulting was nine and a half inches when measured in the same direction. He justly observes, "if they moult more than once in the year, this would make their growth rapid; and if they do not, they must attain an age of not less than eight years before reaching the size that indicates adult life."

The same excellent naturalist observes, "every spring, as soon as the water has lost its winter temperature, large numbers of the young of the previous summer are found in the shallows. These range from an inch to two and a half inches in the shorter diameter. As the creature, when beginning life for itself, is scarcely a quarter of an inch in diameter,

[1] Op. cit., p. 257.

this would imply rapid growth, and I think that the larger of the above have probably lived through two winters" (op. cit., p. 262).

On the Spawning of Limulus polyphemus.

From an actual experiment made by the Rev. Samuel Lockwood it would appear that the female King-crab spawns twice every year, the breeding-season extending over the months of May, June, and July. They come up during the great high tides, spawning under water near the line of high-water mark; thus the eggs are daily exposed to the sun's warmth for a short time at low water.

At this season they come up in great numbers in pairs, the male grasping the sides of the female's shield with his strong and peculiarly modified chelate antennæ.

The eggs, measuring fully half a pint in quantity, and about the size of millet seed, are deposited by the female in a hole in the sand, and are fecundated by the male *after deposition*, and then left to hatch.

This is unlike the behaviour of most of the Crustacea, which, as a rule, appear to fecundate the ova by a true union before the eggs are discharged from the ovaries.[1]

The eggs in the majority of the Crustacea are borne by the female either in an egg-pouch, or *marsupium*, formed by a modification of a certain number of pairs of the thoracic appendages, or adhering by a viscous secretion to the hairs of the abdominal feet (as in the Crab, Lobster and Prawn), until they are hatched.[2]

The ovipositing of *Limulus* may serve to explain the origin of the masses of fossil eggs met with in the shales of the Old Red Sandstone of Forfarshire and Trimpley, near Bewdley, Worcestershire, formerly called *Parka decipiens*, and now referred to *Pterygotus*,[3] for the Eurypterida, like the Xiphosura, may also have left their eggs in the shallows to hatch.

From the experiments of Dr. Lockwood it would appear that the eggs of *Limulus* are slow to hatch. Thus a batch which he preserved occupied seventy days after spawning

[1] To this rule there are some exceptions. In the Anomoura and Macroura there are no copulatory pouches, and the vulvæ open on the basal joint of the third pair of ambulatory legs. It seems pretty certain, therefore, that in these forms the fecundation of the ova cannot take place until the eggs are actually extruded, as known to be the case in *Astacus fluviatilis* (see a paper by M. Chantran, 'Comptes Rendus,' 15th January, 1872:—"The female crayfish lies on her back, bending forward the tail, and making a hollow, into which the ova are passed, the male depositing the spermatozoa upon the plates of the tail-fan and on the plastron of the female, whose appendages seem coated with a greyish viscous fluid").

[2] *Squilla* is said to deposit them within her burrow; *Gegarcinus* deposits them below low-water line on the shore; *Apus*, *Artemia*, *Branchipus*, and *Daphnia* deposit them in the water; *Argulus* fixes her eggs to a stone at the bottom of the water, sometimes to the number of 1500 at once.

[3] See Part III of this 'Memoir,' Pl. XVI, figs. 10, 11.

before hatching; whilst some, set aside at the end of the season in a jar of salt water, hatched out *after some three hundred and fifty days* from the time of spawning.

He very justly estimates the rate of hatching to be due to the greater or less exposure to light and warmth and to the oxygenation effected by the constantly shifting tide-wave and the occasional exposure in damp sand or mud to the sun's rays at low water.

This exceeding vitality and fecundity may best explain the persistence of this genus in time, a persistence probably unsurpassed by any among the Crustacean class save the Entomostraca alone.

Embryology of Limulus Polyphemus.

So long ago as 1838 Professor H. Milne-Edwards[1] had examined the eggs of *Limulus* containing the young ones about to be hatched; he found that at this stage of their development they present very little difference in the conformation of the anterior portion of their body from that which exists in the adult; but the abdominal portion of the body bears only three pairs of appendages, and the long styliform tail-spine, so remarkable in the adult, does not exist at all; the form of the abdominal portion likewise is equally different at this epoch.

No further observations on the development of *Limulus* were made until the years 1869 and 1870, when the Rev. Samuel Lockwood, residing at Rariton Bay, New Jersey, U.S.A., communicated the results of a series of observations made on the "Horse-foot-crab" on that coast to the New York Lyceum of Natural History in October, 1869.[2]

Two valuable memoirs on the development of *Limulus polyphemus* have appeared (1) by Dr. Anton Dohrn,[3] 1871, (2) by Dr. A. S. Packard, jr.[4] (Preliminary paper 1870 and full memoir, 1872.)

We propose to quote chiefly from Dr. Packard's memoir as being the most recent, and also because he enjoyed greater facilities, both on account of frequent visits paid to the coast, and also by constant inter-communication with Dr. Lockwood residing at Rariton Bay, New Jersey, one of the regular resorts of the "Horse-foot-crab," as *Limulus* is there called. During the progress of Dr. Packard's investigations, which extended over

[1] "Sur le Développement des Limules; Société Philomatique," extr. 'Proc. verb.,' pp. 125, 126; 'l'Institut,' vi, No. 258, 1838, p. 397.

[2] Since published with additional matter in the 'American Naturalist,' vol. iv, July, 1870, pp. 257—274.

[3] "Zur Embryologie und Morphologie des *Limulus polyphemus*;" von Dr. Anton Dohrn ('Jenaische Zeitschrift,' Band vi, Heft 4, p. 580, Tafeln xiv and xv), received September 30th, 1871.

[4] "On the Embryology of *Limulus polyphemus*," by A. S. Packard, jun., M.D. Read before the American Association for the Advancement of Science, August, 1870 ('American Naturalist,' vol. iv, No. 8, October, 1870, p. 498).

"The Development of *Limulus polyphemus*," by A. S. Packard, jun., M.D., read November 16th, 1870, 'Mem. Bost. Soc. Nat. Hist.,' vol. ii, 1872, pp. 155—202, 3 plates, 4to.

two years,[1] he was supplied by Dr. Lockwood, in the Springs of 1870 and 1871, with numerous specimens of the freshly laid eggs of *Limulus* for examination, and he pays a well-earned tribute to the ardour and enthusiasm of this excellent naturalist to whose original observations we are greatly indebted for the present state of our knowledge of the early stages in the life of this remarkable Crustacean.

The freshly laid eggs of *Limulus* measure ·07 of an inch in diameter, and are green in colour.

The annexed figures (Woodcuts, fig. 74—77) introduce us to some of the earliest appearances presented by the ova observed under the microscope by Dr. A. S. Packard.

Earliest stages in the Embryology of the *Limulus polyphemus* (after Packard).[2]

FIG. 74. Fig. 75. FIG. 76. FIG. 77.

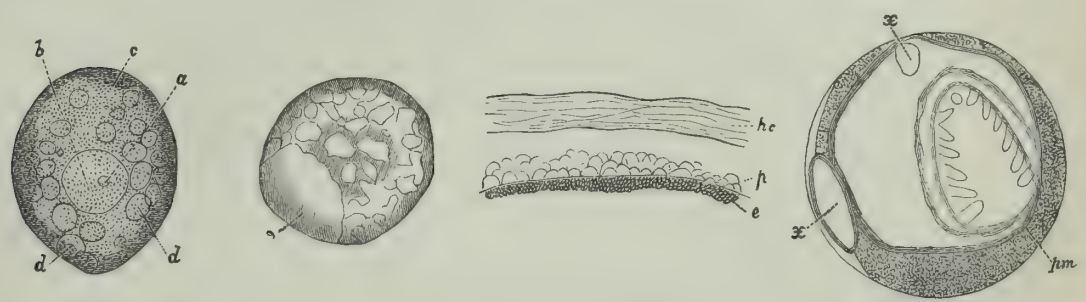


FIG. 74. Cell-egg, with yolk-cells developing. × 130 diams. *a*, the nucleolus; *b*, the nucleus; *c*, layer of protoplasm surrounding the nucleus (germ-yolk); *d*, *d*, yolk-cells developing.

FIG. 75.—Portion of surface of freshly impregnated egg after the primitive cells have disappeared. × 30 diameters.

FIG. 76.—Portion of egg seen in section. *ch*, chorion; *p*, protoderm or amnion, not yet moulted; *e*, the blastoderm and yolk-cells. × 130 diameters.

FIG. 77.—Early stage of embryo. *pm*, the amnion; *x*, *x*, yolk-masses detached before the formation of the blastodermic skin. [See also Pl. XXXIII, fig. 1.]

"We see in Fig. 74 the commencement of the formation in the cell-egg of a central mass of larger and denser granules constituting the nucleus (*b*) within which is the hyaline nucleolus (*a*). Round this is the mass of germ-yolk (*c*) in which are recognisable granules round other centres or yolk-cells (*a*).

After impregnation a denser aggregation of the blastodermic cells takes place on the surface (Fig. 75, *c*).

[1] It is proper to mention here that Dr. Anton Dohrn, of Jena, first induced Dr. Packard to seek for the eggs of *Limulus* on the American coast. The specimens examined by Dr. Anton Dohrn, and which furnished the materials for his paper, were supplied to him by Dr. Packard. It is to be regretted that, owing to the distance at which Dr. Dohrn's studies were carried on, he could only examine specimens preserved in spirits, which prevented him from fully completing his researches. He has, however, added some valuable materials towards the completion of our knowledge of the embryology of *Limulus*, for which as well as for other valuable papers on the Arthropoda he deserves our best thanks.

[2] These four woodcuts, engraved for Prof. Owen's "Memoir," 'Trans. Linn. Soc.,' vol. xxviii, 1873, part iii, p. 488, have, with the author's approval, been most kindly lent for this work by the Council of the Linnean Society.

At this stage the periphery of the egg (Fig. 76) shows a separation of the external layer or blastodermic cells (*e*) into protoderm or amnion (*p*) and chorion (*ch*).

"So far as I am aware (writes Dr. Packard) *Apus* is the only other Crustacean in which a 'protoderm' like that of *Limulus* is formed. It is not comparable with the nauplian or larval skin, as it is composed of distinct cells and is entirely circular, with no lateral diverticula surrounding the appendages."

Fritz Müller has pointed out[1] that in some Isopoda (as for instance in *Philoscia*) the larval skin is not only without any folds or sac-like diverticula, but is closely applied to the egg-membrane.

Certainly when the embryo *Limulus* first appears its position is the same as in *Asellus*, *Ligia*, *Philoscia*, and other Isopods, *i. e.* with its ventral surface convex[2] (see Woodcut, fig. 77 and Pl. XXXIII, figs. 1 and 2).

The egg at this stage has two membranous envelopes, a dense inelastic 'chorion' and an inner elastic 'protoderm.'[3] This chorion remains entire so long as development is arrested or is sluggish, but as soon as the embryo increases in size, the tough inelastic chorion splits asunder, and the inner elastic protoderm enlarges, becomes dense, and vicariously fulfils the duties of the former.

Dr. Packard thinks that no particular taxonomic importance can be attached to the presence of this inner membrane, but that it is simply a biological matter having reference to the circumstances under which the eggs are deposited. He reminds us that the eggs of *Limulus* are laid loose in the sand and remain there, or are washed about by the waves during a month or six weeks, and possibly over a whole season.

In the case of *Apus* (whose ova are similarly provided with a chorion and protodermal envelope) the female lets her eggs fall at random to the bottom of the water, where they remain until hatched by the sun's warmth—a process which occupies two or three weeks. The chorion splits as in *Limulus*, and during the subsequent changes of the embryo the semi-transparent inner egg-membrane (' protoderm ') takes its place.

Whilst fully admitting the undoubted utility and fitness of this duplex envelope which, like the ephippial capsules of *Daphnia*, may have to undergo the severest trials in protecting the fertilised ovum within, often through protracted periods of delayed exclusion; it nevertheless seems only philosophical to homologise if possible these embryonal investments of the young of the several orders of Crustacea. For although so ephemeral in their nature and varying in character according to the conditions under which the young are placed[4] they help us, as Claus, Darwin, Fritz Müller, and other

[1] 'Facts and Arguments for Darwin,' translated from the German by W. S. Dallas, F.L.S., London, 1869, 8vo, p. 71.

[2] H. Woodward, article "Crustacea," p. 649, vol. vi, 'Encyclopædia Britannica,' 9th edition, 4to, 1877.

[3] Dohrn calls the inner membrane in the egg of *Limulus* the "chorion," and the outer the "exochorion," but Packard's term *protoderm* appears preferable.

[4] Many of the Amphipoda and Isopoda display the most assiduous care for their young, and, like

carcinologists have shown, to bring together many of the aberrant members of the great Crustacean class, which are hopelessly isolated from one another in the adult state, but are at once recognisable in their larval dress.

The formation of the blastoderm accords with that of *Gammarus*, *Asellus*, &c., and also, according to Prof. Owen, with Arachnids, the yolk not undergoing segmentation.

§ 7. *Formation of the embryo.*—"Between one and two weeks after the eggs are laid (*impregnated?*) the primitive disk appears, bearing six pairs of appendages (see woodcut, fig. 77). The appendages become more prominent and in a day or two more appear as distinct tubercles." (See Pl. XXXIII, fig. 1.)

In the succeeding stage of development figured both by Drs. Dohrn and Packard (see Pl. XXXIII, fig. 2, after Packard), the oval body of the embryo has increased in size; the separation into cephalic and thoracico-abdominal divisions has taken place; the mouth-opening is seen, and the rudimentary six pairs of appendages are readily made out. The first pair are well marked by their position in front of the mouth and their minute size; in like manner the sixth pair are distinguished by their greater development and modified form. Dr. Dohrn also detects in this stage the under lip ;[1] but his drawing does not show it very clearly. This is followed by the rudiments of the first thoracic plate bearing in the adult the ovaries, and marked in Dr. Dohrn's figure of the embryo by two pores. Behind these come the rudiments of the first two pairs of branchiferous plates not yet outspread. The abdomen is then, as afterwards, destitute of appendages. The 'arthomeres,' or body-rings, are also indicated beyond the areola, the sutures extending upwards but not reaching the dorsal side of the egg. These changes occur some time before the splitting apart of the chorion. The cephalic feet have increased in length and are folded upon themselves. To this period of development Dr. Packard has given the name of the subzoëal stage.

In another egg (Pl. XXXIII, figs. 3 and 4), the chorion of which had not yet split apart, the six cephalic and nine thoracico-abdominal segments are well seen, the sutures forming deep depressions in the yolk, which is pale green as before, and lobulated just within the integument. The bases of the limbs are nearer together, and the line between the cephalic and thoracico-abdominal segments may be distinctly seen, the posterior edge of the former projecting out sensibly beyond the sides of the abdomen. The two basal pairs of abdominal feet (*h g*) have become more prominent, being thinner and more lamelliform, the third pair (*i*) being still minute.

Referring to the early stages of the embryo of *Limulus* (Woodcut, fig. 77, and

Mysis, are provided with a marsupium, in which the larvæ undergo their metamorphosis; and the offspring often pass a considerable time after attaining the perfect state. In these orders we find the young issue from the egg in a far more helpless and immature condition than in *Limulus* and some other Crustacea whose eggs are abandoned by the parents, reminding one very forcibly of the similar disparity of development in the young of Insessorial as compared with Rasorial and Natatorial birds.

[1] "Metastoma," H. W., "chilarium," Owen.

Pl. XXXIII, figs. 1 and 2) Dr. Packard compares it with the free-swimming "nauplius" condition of Entomostraca, especially of the Copepoda. He admits, however, that the differences are very great, and that probably other observers will not share this opinion.[1]

The stage which follows (see Pl. XXXIII, figs. 3, 4, and 5, copied from Packard) is distinguished by the differentiation of the thoracico-abdominal series, and the appearance of a third pair of rudimentary thoracic limbs, together with the first indications of the chelæ. The compound eyes are also seen as two white dots on the third segment of the cephalon. The ocelli appear still later and are situated near the centre of the anterior border. The nine thoracico-abdominal rings are indicated, no more being added during after life. There are six cephalic rings, indicated by deep emarginations on the head-shield, reaching even to the glabella. The whole body in the embryo is spherical, being as thick through as it is wide. "At this stage the chorion bursts open, the protoderm increases greatly in size, aad a corresponding amount of sea water is absorbed (by endosmosis) in which the embryo floats."

Dr. Packard observed this larval skin moulted, the process occupying two or more days owing to the want of aëration in the water, and the consequent sluggish condition of the embryo. The skin was pulled off from before backwards, and might afterwards be seen floating about in the protodermic fluid or entangled in the limbs of the embryo.

He at first believed this to be a 'nauplius' moult, but was subsequently led to consider it as analogous to the third moult in *Asellus*, described by van Beneden[2] in his Memoir on that genus. Prof. van Beneden has also pointed out that certain Anchorellæ and some Lerneopoda, after undergoing a first or blastodermic moult, accomplish a second or nauplian moult, which occurs when the embryo is provided with three pairs of appendages characteristic of the form of "Nauplius." This corresponds, he thinks, to the larval skin of *Ligia* and the nauplius skin of *Mysis*.

"In this second cuticle the embryo continues to develop, and we see a series of six pairs of appendages make their appearance in the Anchorellæ and five in the Lernæopoda. It then secretes a third skin which is the cyclopean or zoëal skin, and the young *Anchorella* and Lerneopod come into the world under this form (op. cit., p. 166).

As the young *Limulus* increases in size the yolk is gradually absorbed, and the body

[1] We have elsewhere observed that "the greatest caution should be exercised in instituting comparisons between the so-called 'nauplius' and 'zoëal' stages of any one Crustacean when such stages are passed *within* the egg and those of any other Crustacean whose young (as in the Copepoda) actually pass through such stages *after they have quitted the egg*.

"In the Decapoda we know of only one instance in which the young appears as a free-swimming 'nauplius;' in the majority we see only the 'zoëal' and 'larval' stages; in some even the zoëal stage is overleaped, and the young appears as a larva differing but little from the parent."—['Encyclop. Brit.,' 9th edition, 1877, article "Crustacea," by H. Woodward, vol. vi, p. 650.]

[2] "Recherches sur l'Embryologénie des Crustacés. 1. Observations sur le Développement de l'*Asellus aquaticus*," 'Bulletins de l'Académie Royale des Sciences, etc. Belgique,' 2me série, tom. xxviii, 1869, p. 54.

becomes flatter and expands laterally; the cephalic shield increases in breadth, and the hinder body is curved upon the cephalon, the larva assuming the position of an Amphipod in the egg, with its dorsal surface convex instead of its ventral surface, which is now concave. This stage, described by Packard, may probably be that figured by Dr. Dohrn, and copied by us from his memoir (see Pl. XXXIII, fig. 9). In this figure the differentiation of the articuli of the limbs has proceeded further than in fig. 4, the opercular and first and second thoracic branchial plates (*op.*, *br.*) and the rudimentary 'metastomata' or 'chilaria' (*ch.*) are also discernible, and the chelæ some free, others still apparently enclosed at their ends in the simple finger-tips of the previous moult.

Lastly, just before hatching, what Dr. Packard calls "the trilobitic shape" (Pl. XXXIII, figs. 6, 7, and 8) is assumed. This stage is peculiarly interesting to the palæontologist as well as to the embryologist as illustrating some points in the structure of the extinct members of the order not seen in the fully developed living King-crabs. Thus, in the deeply-emarginated head-shield of young *Limulus* at this stage, one is led to recall the indication of segmentation in the cephalon of *Hemiaspis* (see Woodcut, figs. 64 and 68, p. 178). We are also furnished with a means of interpreting the curious punctate or digitate structure of the margin of the head-shield in *Trinucleus concentricus* (see Pl. XXXII, figs. 38—41). The late Mr. J. W. Salter[1] supposed that the membranous margin of the head-shield of *Trinucleus* was once entire, "then became plicate, then perforate, and lastly separated into linear processes" (fig. 40 *l*). It appears to us more in accordance with the observed mode of evolution of the head-shield in larval *Limulus* (Pl. XXXIII, figs. 4, 6, 7, 12) to conclude that the margin of the head-shield in *Trinucleus* was originally digitate, then gradually closed up, leaving only perforations along the sutures in some, and only plicæ in others.

We have an analogous modification of the shells of certain Mollusca, *e.g.*, *Haliotis*, *Scissurella*, and *Pleurotomaria*, in which a slit becomes partially or wholly closed, leaving a furrow with perforations at intervals. It must be borne in mind that in these Gasteropods the structure referred to is connected with the respiratory functions, but in *Limulus*, *Hemiaspis*, and *Trinucleus* it indicates the margins of the primitive segments which have coalesced to form the cephalic shield.[2]

This trilobite stage of larval *Limulus* proves, if further evidence were wanting, that the front shield of *Limulus* is the head (cephalon), and *not the cephalothorax* (as erroneously called by Dr. Packard). In this view I am in accord with Professors Owen and Huxley, Mr. C. Spence-Bate, and other carcinologists.[3]

In like manner the hinder-body of the young King-crab (Pl. XXXIII, figs. 6 and 12) at this period serves admirably to illustrate the adult *Limuli* of palæozoic times.

[1] 'Quart. Journ. Geol. Soc.,' vol. iii, 1847, p. 252.

[2] H. Woodward, article "Crustacea," 'Encyclop. Brit.,' 9th edition, 1877, vol. vi, p. 650.

[3] See "Further Remarks on the Relationship of the Xiphosura to the Eurypterida and to the Trilobita and Arachnida," by H. Woodward, 'Quart. Journ. Geol. Soc.,' 1872, vol. xxviii, pp. 46—63.

In the trilobed character of the body-rings with freedom of movement between each of the several segments we see recalled to life its remote ancestors *Neolimulus* of the Silurian epoch (Pl. XXXI, fig. 8), and *Bellinurus* (Pl. XXXI, figs. 1, 3, 4) of the Coal period. The presence of nine segments lends further confirmation to the correctness of our views, already so often expressed in the earlier parts of this Monograph and elsewhere, that we have evidence here not only of the entire thoracic series, but also of a rudimentary abdomen of which the ninth (the telson) represents the hinder somites arrested in their development, as indicated by the like condition of the post-thoracic series in *Hemiaspis* (see Woodcut, fig. 64, p. 177), and in the tendency to divide up into segments seen in the telson of *Stylonurus* (see Woodcut, fig. 73, p. 200).

" The trilobate character of the surface of the body, says Dr. Packard, is very marked, the cardiac or median region being considerably raised above the sides and on the thorax and abdomen; the sutures do not run continuously across the tergum, but are interrupted at the edge of the cardiac region, thus making the latter more distinct. The sutures between the segments are sinuate, as in the trilobites. The outer edge of each segment is convex, the convexity being greatest on the hinder portion of the edge as in the Trilobites. The branchigerous thoracic feet are still very small, and the median sinus between each is greater in the first than in the second pair. The maxillipeds are much as in the larva, the coxal joint being furnished with a stout spine directed inwards; but it is not until after several moults that the numerous spines which form the masticating surface appear.

" The chelæ are acute and long, the six spatulate spines on the penultimate joint of the sixth pair in the adult being now represented by simple spines, and the terminal forceps being quite complete.

" Just behind the last pair of maxillipeds are a pair of oval rather flat tubercles; their bases are united on the median line of the body, thence diverging outwards. These tubercles do not appear much before this period of the life of the embryo. They have no connection with the last pair of maxillipeds, nor can they be, as Savigny supposed, the rudiments of a seventh pair of legs, otherwise they would have appeared earlier in embryonic life. They are seen in Figs. 8, 9, and 11 (*ch.*), Pl. XXXIII, closing up the posterior end of the oral groove.

" In adult life they are movable at their bases and armed on their inner side with recurved spines, like those upon the maxillipeds; hence they serve the purpose of completing the circumoral armature, and also of retaining the food undergoing trituration preparatory to deglutition. Savigny considered them to form a sort of inferior lip." We are in accord with Professors Huxley, Hall, Owen, and others in considering these as the homologue of the broad heart-shaped metastoma or post-oral plate (Woodcut, fig. 71, p. 180) which closes the buccal aperture behind in the Eurypterida (see Parts I—IV of this Monograph).

Its great development in *Pterygotus* seems correlated with the difference in the form and functions of its jaw-feet as compared with those of *Limulus*.

"The ocelli are situated, in an earlier period of this stage than that represented by fig. 6, on the underside of the head just in advance of the mandibles, and are at this time white and irregular in shape, being a little longer than broad. A little later they appear on each angle of the front edge of the cephalon, the edge being afterwards expanded and extended, so that, as in fig. 6, they are placed a little way in from the edge. The eyes also are at first rounded white tubercles, becoming in more advanced specimens black along the front edge. The protoderm measures at this period ·13 of an inch in diameter. Of the eggs laid in the middle of May one was hatched June 30th, the majority came out of the egg about the 14th July, and the remainder kept hatching until the last of September in my jar. In the succeeding summer (July, 1871) the hatching jar, in which the water had remained unchanged since the previous October, and with no weeds to oxygenate the water, contained several embryos in eggs laid during the preceding year, in different though advanced stages of development, and also several larvæ hatched during 1870, though in a torpid state, due probably to the little air in the water. I much doubt whether the eggs of any other living Crustacean would show as much vitality. It should also be noticed that those eggs had not probably grown during the winter, but remained as it were in a state of suspended animation from October to July, a period of nine months. These facts confirm the remarkable observations of Rev. Dr. Lockwood on the wonderful vitality of the eggs of *Limulus*."[1] (See *ante*, p. 213.)

There is a considerable difference (probably due to age) between Dr. Dohrn's 'Trilobiten-Stadium' (see Pl. XXXIII, fig. 12) and that so called by Dr. Packard (Pl. XXXIII, fig. 6). Dr. Dohrn's figure agrees better with Dr. Packard's later stage, the freshly hatched young (Pl. XXXIII, figs. 10 and 11). The segmentation in the cephalon of fig. 12 has entirely disappeared, although the hinder body is still distinctly segmented, and the segments were no doubt to some extent movable. In fig. 10 (copied from Dr. Packard) the division of the hinder body into segments is obliterated save along the central axis.

In its earlier stages the young *Limulus* can fold its posterior segments under its head-shield, and when it at last quits the egg, before having undergone the first moult subsequent to hatching, it is very lively, walking over the jar, and burrowing in the sand at the bottom and occasionally swimming to the top, or skimming obliquely over the bottom by vigorous strokes of its thoracic feet. Mr. Alexander Agassiz once captured a specimen swimming on the surface three miles from shore. This fact indicates that this species owes its wide range, from Maine to the Gulf of Mexico and the West Indies, to the swimming habits of the larvæ.

The principal differences from the embryo just before leaving the egg are these :—the thoracico-abdominal shield is larger than the cephalic one; the sinuate sutures defining the segments of the post-cephalic somites are nearly obsolete, and the hepatic lobes which gave so strongly-marked a character to the head-shield in figs. 4, 6, and 7,

[1] A. S. Packard, junr., op. cit., p. 168.

Pl. XXXIII, do not reach so near the edge of the carapace and cease to affect it by the appearance of sutures on the surface. The edge of the head-shield is fringed with hairs.

The edge of each segment of the thoracico-abdominal somites is toothed, the basal tooth being the largest, the succeeding ones more minute, and with a movable spine inserted on the posterior border of each serration and projecting beyond it (see figs. 10, 11 and 12, T, A, Pl. XXXIII). The border of these somites is also fringed with minute hairs.

Appearance of young Limulus after the first moult.

The first moult observed by Dr. Packard occurred about the 25th of July, three weeks after hatching. The principal changes are the possession of a short abdominal spine, the origin of a fourth pair of thoracic branchigerous lamellæ, and the appearance of additional joints to the opercular plates, and the smaller and more numerous lobes of the liver.

Regarding the age of sexual maturity, and the period when the external male characters appear, Dr. Lockwood thinks that the time of puberty cannot come before the third or fourth year, and considers that the latter figure may prove the minimum. It is not until this period is reached that "the male undergoes its last metamorphosis." It then moults, and the antennal claws assume the peculiar shape of that sex[1] (see Pl. IX, fig. 1 *a*).

The Zoological position of Limulus considered.

Having briefly described the larval stages of *Limulus* I will pass at once to the conclusions arrived at as to the position of *Limulus* with regard to the other Crustacea.

Whether *Limulus* does or does not descend from a Nauplius, Dr. Dohrn considers that at present we have no knowledge of a Nauplius-stage in that genus, any more than in the Trilobita; but the subsequent stages agree with such forms as *Trinucleus* and *Sao*, in the gradual development of the young from a form having a simple cephalic and caudal plate to the adult stage in which numerous intermediate body-rings have been added. Dr. Dohrn further concludes that *Limulus* cannot be retained among the Crustacea, for two reasons. 1st. Because of the presence of only one pair of extremities which are supplied with nerves from the supraœsophageal ganglion.[2] 2ndly. From the position and form of the under lip.

[1] When adult, the males in *Limulus moluccanus* have the chelæ of both the 2nd and 3rd pair of appendages modified, so as to form powerful recurved monodactylous claws, which shut against a projection from the penultimate joint. (Vander Hoeven, *op. cit.*, pl. i, fig. 3.)

[2] This was first asserted by Vander Hoeven in his 'Recherches sur l'Histoire Naturelle et l'Anatomie des Limules,' 1838.

1. "Bearing in mind that *all Crustacea* have two pairs of antennæ receiving nerves from the supraœsophageal ganglion, thus distinguishing them from the Spiders, Myriopoda, and Insects, it is (says Dr. Dohrn) impossible to ignore that the presence of only one pair of extremities (the antennules) in *Limulus* so supplied with nerves separates it from the Crustacea. And, further, to which of the two pairs of antennæ, and therefore to which of the two anterior pairs of extremities, in Nauplius does this first pair in *Limulus* correspond ?" "This question," he adds, "we must leave entirely unanswered, as we have at least hitherto been unable to detect any trace of a rudimentary second pair either before or behind this first pair."

Dr. Dohrn therefore concludes that *Limulus* cannot be retained with the Crustacea, but must be classed with Spiders and Insects which have only one pair of antennæ.

2. With regard to the under lip (metastoma) Dr. Dohrn says that in all the Crustacea it is a fold of the germinal membrane behind the mouth. It is found on a level with the mandibles, or sometimes even in front of them. In *Limulus* the under lip is *behind* the sixth pair of appendages, and is divided into two parts.

This led Dr. Dohrn to suspect that it might prove to be really *a seventh pair of appendages;* but this point he has been unable to clear up; for, owing to the fact of his specimens having been preserved in spirit, he could not satisfactorily make out whether or not it has a separate nerve-ganglion. He, however, concludes that "these two peculiarities make it improbable that *Limulus* belongs to the Crustacea."

Dr. Dohrn remarks that "what Savigny has hinted at, and what Strauss-Dürckheim has one-sidedly expressed, reappears now under the light of the theory of evolution. The connection of the Arachnida with the Crustacea is probably through *Limulus* and the Eurypterida," as indicated by myself in 1866 (see 'Quart. Journ. Geol. Soc.,' vol. xxiii, p. 35).

In comparing the *Limuli* and *Eurypteri* with the Arachnida one naturally turns to the Scorpionidæ as the group most suitable for that purpose.

Both in *Pterygotus* and *Scorpio* we find the antennary system modified in the same manner, not only in form but in function also; the larval ocelli are seen in both; the locomotory appendages are all cephalic in both; and the elongated body, with its peculiar trapezoidal head-shield, its enlarged thoracic segments (the first in both) bearing the reproductive organs on the underside, and the more slender abdominal series followed by a broad apiculate tail-joint, naturally seems to invite a comparison of the two groups. But the respiration in the former is performed aërially by pulmonary sacs, arranged in pairs along the ventral borders of the thoracic segments; whereas in *Limulus* and *Pterygotus* the respiration is performed by branchiæ borne on the same series of segments (the thoracic) in *Limulus*, and by one or two only of the same in *Pterygotus*. But, on the other hand, the great cordiform under lip of *Pterygotus* and the two pieces homologous therewith in *Limulus*, the broad thoracic plate or operculum in both *Limulus*

and *Pterygotus*, and also the large compound eyes and the respiratory system in both, differ entirely from any structure to be found amongst existing forms of Arachnida. I long held the opinion that the organs called combs in the Scorpion were homologous with the branchial leaves of *Pterygotus:* they are, so far as I am aware, aborted organs in *Scorpio*, although they are supposed to fulfil some excitatory function in connection with the impregnation of the ovaries: may they not probably be homologous with the opercular plates of *Limulus* covering the branchial plates, and bearing the orifices of the reproductive organs on their inner surface?

As I have elsewhere stated, there is no insuperable difficulty in accepting, on sound physiological grounds, the possibility of any animal passing through larval conditions, casting aside at even a single moult its branchiæ, and assuming aërial respiration, quitting the water and inhabiting the land, changing its element, its diet, its mode of progression, and its entire life. Such cases are familiar to the entomologist,[1] the carcinologist,[2] and even to the herpetologist.[3]

From his examination of the embryonal changes of *Limulus* Dr. Dohrn has been led to observe how remarkably the young stages agree with the youthful *Sao hirsuta* and *Trinucleus ornatus;* indeed, he might well add, with the young of *Agnostus*, *Aulacopleura*, *Phacops*, *Hydrocephalus*, and with every Trilobite of whose infancy the researches of the illustrious Barrande has made us acquainted (see Pl. XXXII).

He also notices the remarkable analogy which the nearly mature embryo presents to *Bellinurus* and *Prestwichia*—a resemblance which I had previously pointed out in my paper already referred to ('Quart. Journ. Geol. Soc.,' 1866, vol. xxiii, pp. 34—35).

I will now quote the final paragraph from Dr. Dohrn's paper, and then give my reasons for dissenting from his conclusions.

"The more the theory of evolution is allowed a direct influence in zoological work, the more conspicuous is its pre-eminently practical character, inasmuch as it not only solves problems, but also suggests a correct method of inquiry. Thus, it is true, it destroys the traditional system; but it sets up a new one immediately; and thus, if we ask for the result of its application as made in the present memoir, we arrive at the following conclusions:

"*Limulus* is most nearly related to the Gigantostraca; both seem to be related to the Trilobites, although it is not possible to demonstrate all the details of their relationship. The morphologico-genealogical relations of these three families to the Crustacea

[1] Larval and adult *Libellulæ*, *Ephemera*, &c.

[2] *Gecarcinus ruricola* and other Land-crabs.

[3] The Batrachia.

[4] Prof. Häckel believes the Trilobites to be a suborder of the Phyllopoda, from which, *perhaps*, the Pœcilopoda descended. He again divides the Pœcilopoda into two legions, viz. the Xiphosura and Gigantostraca. (See his 'Generelle Morphologie,' the Gigantostraca being *Pterygotus*, *Eurypterus*, &c.) In this view Gegenbaur agrees with Häckel.

cannot at present be established, and perhaps may always remain doubtful. It is also impossible at present to say anything definite concerning the relationship between them and the Arachnida. Therefore all we can do is to combine these three families under a common name, for which I would propose Häckel's expression 'Gigantostraca,' and to place them in the system beside the Crustacea."

To conclude, then:

According to Dr. Packard there is a Nauplius-stage passed by *Limulus* in the egg. (He, however, does not seem quite to understand what is meant by a Naupliform larva.) He admits that it is not like the "Nauplius" of *Apus* or of *Branchipus*, but is to be compared rather to that of the Trilobites, a knowledge of which we do not possess.

If *Limulus* is brought *nearer* to Trilobita through the discovery of the specimens of *Asaphus* by the late Mr. E. Billings, F.G.S. (figured in 'Quart. Journ. Geol. Soc.,' 1870, vol. xxvi, p. 479, pls. xxxi and xxxii), we have failed to understand its nature. The specimen is believed to possess *eight* pairs of five-jointed walking-feet attached to the movable thoracic segments of the body, not a series of mouth-feet (gnathopodites), as in *Limulus*, but rather like the thoracic legs in the Isopoda.

That which really does bring the Trilobites near to *Limulus* is the series of embryonal changes passed through by the latter in the egg, which resemble the young of the former, and also the young state in the Ispoda.

Thanks to Professor Owen, I am now in a position to rebut Vander Hoeven's and Dr. Dohrn's arguments as to the presence of only one pair of anterior extremities supplied with nerves from the supraœsophageal ganglion, and to show by the admirable series of dissections of the nerves drawn on Pls. XXXIV, XXXV, and XXXVI (reproduced from Professor Owen's Monograph), that, as in other Crustacea, *Limulus* possesses two distinct pairs of appendages (antennules and antennæ) which derive their neuration from two pairs of nerves arising from the front of the supraœsophageal ganglion. Van der Hoeven's statement must therefore be considered as incorrect.

He further confirms the statement made by me ('Quart. Journ. Geol. Soc.,' 1866, vol. xxiii, p. 33), that the thoracic or opercular plate derives its innervation from a cephalic ganglion, whereas the succeeding inner posterior branchigerous plates are appendages of the thoracic somites.

Concerning the Eurypterida, so far as our present knowledge extends, I must adhere to my already published conclusion, namely, that one pair of antennary organs is suppressed[1]—a strong argument in favour of the theory of the retention of larval characters by these palæozoic forms.

With regard to the under lip (*metastoma*), it seems singular to base the refusal of a place to *Limulus* among the Crustacea upon the fact that the metastoma is rudimentary, whereas in *Pterygotus* it is very large, formed in one piece, having a ridge in the mesial

[1] According to Spence Bate and Fritz Müller the second pair of antennæ are absent in the females of *Brachyscelus*, although the male possesses them like other Amphipods.

line. In the Trilobita it is wanting, and in place of it we have a largely developed hypostome, or upper lip, fulfilling the function of assisting the maxillæ to retain the food in the same manner as does the hypostome in *Apus*. Yet the Trilobita and Eurypterida (one with a hypostome, and the other with a metastome) are placed by Dr. Dohrn together in one section, *beside* the Crustacea. The development of this very organ in larval *Limulus* was one of the points which Dr. Dohrn was unable to clear up.

As to Dr. Dohrn's proposal to remove the Merostomata and the Trilobita from the Crustacea and place them in a separate class beside the Crustacea, and to include with them the Arachnida, I have made elsewhere[1] the following remarks :

"It is no difficult matter to pull down a system of classification ; but it is only right to demand that this should not be done upon insufficient grounds.

"Heretofore, in the formation of zoological groups, it had been the custom (long before embryology became so important a branch of study, or was so well understood as it is at this day) to take the sum of all the characters which the species presented, giving due value and weight to each ; and this method has been adhered to in the classification both of the animal and the vegetable kingdom by all our leading naturalists.

"The introduction of embryological investigations has furnished an additional and conclusive support in most cases to the results of the exhaustive method of examination already applied to the adult form, seldom aiding us so much in differentiating group from group as in pointing out affinities, and thereby inviting us to throw down boundaries (hitherto scrupulously guarded by the systematic naturalist) and to merge together larger and yet larger groups.

"Before this is done all I would beg is, that the facts and evidences for maintaining the existing arrangement may be carefully reconsidered.

"If we are contented to conclude with Dr. Dohrn that 'the morphologico-genealogical relations of these three families of Crustacea (viz. Limulida, Eurypterida, and Trilobita) cannot at present be established, perhaps may always remain doubtful,' and that we should therefore combine them under one collective name, '*Gigantostraca*,' placing them 'beside' the Crustacea, we lay ourselves open to the grave charge of destroying an established system without" offering any good ground for "setting up a new one in its stead.

"Take away the Trilobita from the pedigree of the Crustacea, and I submit that one of the main arguments in favour of evolution to be derived from the class, so far from being strengthened, is destroyed. From what are the Crustacea of to-day derived? Are we to assume that they are all descended from the Phyllopods and Ostracods—the only two remaining orders whose life-history is conterminous with that of the Trilobita? Or are we to assume that the Arachnida are the older class?

"'If,' as Fritz Müller well observes, 'all the classes of the Arthropoda (Crustacea, Insecta, Myriopoda, and Arachnida) are indeed all branches of a common stem (and of this

[1] 'Quart. Journ. Geol. Soc.,' 1871, vol. xxviii, p. 59.

there can scarcely be a doubt), it is evident that the water-inhabiting and water-breathing Crustacea must be regarded as the original stem from which the other (terrestrial) classes, with their tracheal respiration, have branched off.' "[1]

As regards the near relationship between the aquatic gill-bearing Xiphosura and Eurypterida, and the terrestrial tracheated Arachnida, we must bear in mind that the rich deposits of the Carboniferous period in Europe and America have yielded numerous examples of both these types. Scorpions and Spiders, differing but little from existing forms, flourished in the Coal-period, and *Eurypterus*, as well as *Limulus*, still survived from Silurian times.

While fully admitting the probability of a common ancestry for the *Scorpionidæ* and the *Eurypterida* we cannot pretend to say that the diverging point is reached at which the latter cast off its aquatic existence and commenced its terrestrial phase as an Arachnid.

Neolimulus, again, is a true Limuloid form, and it occurs as far back in time as *Pterygotus*, or nearly so; and *Hemiaspis*, one of the few intermediate forms met with, presenting characters between the long and the short-bodied divisions of the Merostomata, occurs also in the Silurian strata with *Pterygotus* and *Eurypterus*.

The Trilobita, with a far more remote ancestry than the Merostomata, only end in the Carboniferous period; whilst the Isopoda, with which I have ventured to compare them, have been traced back as far as the Devonian.

By placing in a tabular form the sum of the characters of each order side by side, we are the better able to comprehend the extent to which they are capable of being paralleled; and certainly it seems as if the verdict were in favour of as near a relationship existing between the Isopoda and Trilobita as that which undoubtedly does exist between the Xiphosura and the Eurypterida.

I.

Pterygotus (fossil extinct).	Limulus (fossil and living).
1. Eyes sessile, compound.	1. Eyes sessile, compound.
2. Ocelli distinctly seen.	2. Ocelli distinctly seen.
3. All the limbs serving as mouth-organs.	3. All the limbs serving as mouth-organs.
4. Metastoma, *large*, bilobate, oval.	4. Metastoma small, bifid.
5. *Anterior* thoracic segments bearing either branchiæ or reproductive organs.	5. *All* the thoracic segments bearing either branchiæ or reproductive organs.
6. Other segments destitute of any appendages.	6. Other segments destitute of any appendages.
7. Thoracic segments *non-anchylosed*.	7. Thoracic segments *anchylosed*.[2]
8. Abdominal segments *free and well developed*.	8. Abdominal segments *anchylosed and rudimentary*.

[1] 'Facts and Arguments for Darwin,' by Fritz Müller, with additions by the author. Translated from the German by W. S. Dallas, F.L.S. (p. 120).

[2] Free and movable in the very young state, and probably also in some of the palæozoic species, *e g.*, *Bellinurus* and *Neolimulus*.

II.

Trilobita (fossil extinct).	Isopoda (fossil and living).
1. Eyes sessile, compound.	1. Eyes sessile, compound.
(2. No ocelli.)	(2. No ocelli.)
3. Hypostome *well developed.*	3. Hypostome *small.*
4. (Appendages partly oral, partly ambulatory or natatory, arranged in pairs.)[1]	4. Appendages partly oral, partly ambulatory or natatory, arranged in pairs.
5. Thoracic segments, *variable in number from six even to twenty-six,* free and movable (animal sometimes rolling in a ball).	5. Thoracic segments, *usually seven,* free and movable (animal sometimes rolling in a ball).
6. Abdominal somites coalesced, forming broad caudal shield (bearing the branchiæ beneath).	6. Abdominal somites coalesced, forming broad caudal shield, bearing the branchiæ beneath.

A few words are necessary in explanation as to some points of dissidence between the conclusions arrived at by my friend Dr. A. S. Packard, jr., and myself.

Dr. Packard evidently relies *mainly* on embryology in deciding the zoological position which an animal shall occupy, a line of reasoning which I have felt it my duty on a former occasion most earnestly to deprecate.

Admitting, as I do, most thoroughly the great value of such researches, I nevertheless hold that it is essential to a correct interpretation of an organism to take the sum of all the characters which the species presents, giving due weight to each[2]—a method of investigation in which all our most sound and philosophical naturalists and physiologists are agreed.

1st. As to the comparison between larval *Limulus* and the *Trilobita,* I would observe that before *Limulus* leaves the egg—nay, even when the embryo is little more than a primitive band or disk traced out on the yolk (see woodcut, fig. 77 and Pl. XXXIII, fig. 1), it has *six* pairs of appendages. Dr. Packard states, "I might say that I have examined hundreds (I believe over a thousand) living eggs, as well as those that had been hardened in spirits, in order to ascertain whether the germ first appears with less than six pairs of legs, but without success" (op. cit., p. 200).

At a little later stage Dr. Packard says (p. 165) "there are six well-marked *cephalothoracic* [cephalic, H. W.] segments; the nine *abdominal* [thoracico-abdominal, H. W.] rings have appeared, no more being added during after life."

These facts appear to me to dispose entirely of the attempts to homologise the larva of *Limulus* with the free-swimming Nauplius of the Copepoda on the one hand, or with the young of the Trilobita on the other.

The number of paired appendages concealed beneath the double shield of the infant *Agnostus, Sao,* or *Trinucleus,* we are entirely unable to discover, it cannot there-

[1] Mr. C. D. Walcott's researches on the appendages of the Trilobites are not yet completed.

[2] 'Quart. Journ. Geol. Soc.,' 1871, vol. xxviii, p. 59.

fore be more than a supposition that there is any very close connection between a young Trilobite, such as those represented on Pl. XXXII, and a Limulus, such as we have pictured to us by Dr. Packard (Pl. XXXIII, figs. 1—5), possessed of a head-shield affording evidence of at least *six* (if not of seven segments), and a hinder body (representing according to my view the thoracico-abdominal series) composed of nine segments from its third or fourth moult within the protodermal egg-covering even before the absorption of the yolk takes place.

2nd. As to the position of the eyes, Dr. Packard observed "the compound eyes as two white dots on the third segment of the *cephalothoraæ* (cephalon, H. W.).

"The ocelli (he states) appear still later on in the *mandibulary*[1] or first segment. It is thus proved that the eyes are not in Limulus developed on distinct segments" (op. cit., p. 165). To this I would reply that at this stage most probably, as in some other Entomostraca, the compound eyes are really concealed *beneath* the head-shield. The ocelli, he states, are on the *first* segment; but this is *not* "the mandibular segment" (see pp. 4 and 5 of this Monograph, where, according to Bell, Dana, Bate, and Huxley, the ophthalmic segment is the first, the antennary 2nd and 3rd, and the mandibular the 4th). But of far higher importance in deciding this point is the position of the nerves in connection with the supraœsophageal ganglion, as shown by Professor Owen, whose plates I am permitted to reproduce (see Pl. XXXIV—XXXVI).

Professor Owen remarks "The first pair of nerves is the 'ocellar' (Pl. XXXVI, *a, a* 1); the second pair of nerves is the 'ocular' (ib., *n* A)." Surely if the *supposed* want of two pairs of antennal nerves taking their rise from the front of the supraœsophageal ring was sufficient to induce Dr. Dohrn to wish to remove the *Limuli* from the Crustacean class, the position of the optic nerve ought to have some weight in deciding the segment to which the eyes must really be referred.

3rd. I believe I have almost in every case (save the one pointed out by Dr. Packard in Part I, p. 39) spoken of the post-oral plate as the *metastoma*, not as the *labium*. Dr. Packard in comparing the *Merostomata* with the *Trilobita* (op. cit., p. 190)—a comparison which I cannot consider as a happy one[2]—speaks of the *metastoma* of *Eurypterus* and *Limulus* as the *hypostoma*, and compares it with the *hypostoma* of the Trilobites with which it clearly has nothing in common; since the hypostome of the Trilobite is always in front of the mouth as in *Apus*, attached to the frontal doublure of the head-shield; whereas the great cordiform lip-plate or "metastoma' of *Pterygotus*, and the 'chilaria' (Owen) of *Limulus* are placed invariably *behind* the circumoral appendages, closing effectually the posterior part of the buccal orifice.

4th. There being, according to Dr. Packard's view, no distinct optic segment in *Limulus*, &c., he treats the first segment as antennal.

[1] Possibly this may be a misprint, as elsewhere he speaks of it as the antennary segment.

[2] The reader's attention is drawn to the characters of PTERYGOTUS and TRILOBITA given at pp. 226-7.

He further assumes that there are but five segments in the head of the Eurypterida, each bearing a pair of appendages (and also two pairs of eyes, compound and simple), but this head he regards as a cephalothorax comparable with that of *Limulus*, "the thoracic segments being *potential*, but with one segment less, that bearing the first pair of maxillipeds." Dr. Packard further argues that the head in *Limulus* contains organs which in the Malacostraca are lodged in the thoracic region. To this we would reply that in the Decapoda-Brachyura the carapace, which is formed (not by the thoracic somites beneath it, but) by the coalescence of the anterior cephalic somites (antennal and mandibular rings, Spence Bate), encloses precisely similar organs to those found within the head-shield of *Limulus*, and moreover acts as a roof to the branchial chamber; the branchiæ in the Crabs being attached to the thoracic feet as in the King-crabs, although the feet themselves are so differently modified in the latter.

5th. Dr. Packard has not understood Professor Huxley's explanation that "the ovigerous segment" is considered by him as the last cephalic (or the first thoracic, coalesced with the cephalon), and deriving its nerves from thence as shown by Professor Owen (see ante, p. 196); hence arises a part of the difficulty which he finds in agreeing with me as to the number of segments in *Limulus* and *Pterygotus*. The rest is occasioned by attempting to show that the thoracic somites always remain undeveloped in *Limulus* and *Pterygotus*, and that the head is really the cephalothorax, and the hinder body is the abdomen, with an excessive number of segments as in *Branchipus*. At the risk of seeming tedious we therefore venture once more to summarise our views of the Merostomata.

Eurypterida.	Xiphosura.
I. Cephalon:—Bearing the	I. Cephalon:—Bearing the
1. Ocelli and compound Eyes on the dorsal surface.	1. Ocelli and compound Eyes on the dorsal surface.
2. First antennæ } 1 pair	2. First antennæ.
3. Second antennæ } aborted.[1]	3. Second antennæ.
4. Mandibles.	4. Mandibles.
5. First maxillæ.	5. First maxillæ.
6. Second maxillæ.	6. Second maxillæ.
7. Maxillipeds.	7. Maxillipeds.

[1] Prof. Huxley has suggested that the chelate organs in front of the head in *Pterygotus* represent the antennæ, and that the antennules are aborted. If this holds good the remaining organs will be found to correspond exactly in number with *Limulus*. In *Pterygotus* the basal joint of these first chelæ are non-mandibulate, in *Eurypterus*, *Slimonia*, and *Stylonurus* the first pair are simple palpi, but are mandibulate at their base; this would lead one to conclude that they probably represent the antennules in the first and the antennæ in the last-named species.

(Eurypterida.)	(Xiphosura.)
II. Thorax:—Bearing the	II. Thorax:—Bearing the
[1.[1]] Opercular plate having the ovarian openings on its inner surface.	[1.[1]] Opercular plate having the ovarian openings on its inner surface.
2. Branchiæ.	2. Branchial feet.
3. (Ditto?.)	3. Ditto.
4. No appendages.	4. Ditto.
5. Ditto.	5. Ditto.
6. Ditto.	6. Ditto.
7. Ditto.	7. No appendages.
III. Abdomen (well developed).	III. Abdomen (rudimentary).
No appendages.	No appendages.
1—7. Including the telson.	1, 2. Segments and telson.[2]

The eminent American carcinologist, Professor Dana, writing on *Limulus*, says, "The body consists of three segments, and they may be compared to the segments in *Caligus*. The anterior segment bears six pairs of members; the first appears to correspond to the second pair of antennæ (or third normal segment), the 2nd, 3rd, 4th, 5th, and 6th to the mandibles and the four following pairs of members (or the fourth to the eighth normal segment inclusive).

"The second segment of the body, which we consider as a continuation of the cephalothorax, and not abdominal, bears six pairs of foliaceous organs, analogous to the foliaceous appendages of the posterior part of the thorax in certain *Caligidæ*, in some of which one or two pairs of legs are combined into a hard, thin plate like an apron. These six pairs make up exactly the normal number of cephalothoracic segments, namely, *fourteen*. The abdomen, according to this view, is confined to the last or third segment," *i. e.* the great telson and any portion of the hind-body, the segments of which, though not seen in the adult, are indicated by distinct sutures in the young (see Pl. XXXIII, fig. 12, A and t).

In this sense I shall be happy to adopt the term cephalothorax, but not as applied by Dr. Packard to the head-shield alone.

6th. As to the suggestion that my division between the thorax and abdomen in the Eurypterida "is a purely imaginary one," I will only refer those interested in the subject to the figures of *Stylonurus* (p. 131, fig. 39, dorsal view), in which, as in many other cases, the ornamentation ceases at the end of the thoracic series; to the figure of *Eurypterus* (p. 132, fig. 40), and to the still more striking figure of *Hemiaspis* (p. 177, fig. 64).

7th and lastly. In the method adopted by me in counting the segments I have been actuated by the principle long since suggested by Oken, that, even where a segment is

[1] Both Professors Huxley and Owen have demonstrated that the nerves supplying this opercular plate arise from the cephalic shield.

[2] Prof. Owen has shown that the 'telson' most probably represents the undeveloped posterior abdominal somites as evidenced by the plexus of nerves it encloses within its hard triangular sheath.

not clearly indicated in any annulose animal, the presence of a pair of appendages always marks the existence of a separate segment.

It is not beyond possibility that a second pair of antennæ may yet be discovered in the genus *Slimonia*, in which their presence has been suspected; but in such a case as that of the supposed suppression of one pair of these organs there is warranty for the theory to be derived from other living Crustacea[1] besides that afforded by a comparison with *Limulus*.

Neither the space allotted me, nor the time at my command, permit me to reply at greater length to Dr. Packard's valuable remarks. To answer them as fully as I could wish would involve an additional part to this Monograph.

I have endeavoured to the best of my ability to interpret aright the fossil remains of the ancient order of the MEROSTOMATA, and I must leave the *onus probandi* to those who object to that interpretation.

Whilst tendering my sincere thanks to Professor Owen for the valuable assistance I have derived from his memoir on the American King-crab, I would venture to touch on one or two points in which I beg leave to dissent from his conclusions.

1st. "No observer," says Professor Owen, "has yet testified to their capacity of uplifting the body from the ground, whether dry or submerged, and of bearing it along by successive steps, as do the jointed legs of the Isopod, the Lobster, or the Crab" (p. 495).

To this I would reply that many years since I carefully observed the living *Limuli* in the Fish-house at the Zoological Gardens, Regents Park, and I have there seen *Limulus* trot briskly along upon the floor of the tank, keeping the edge of its cephalic shield raised clear above the level of the sand.

In the spawning season the female laden with eggs not only *walks* to shore, but carries on her back the salacious male holding on firmly to her carapace by his specially modified antenna. "When left exposed by the tide they hasten (says Dr. Lockwood) to overtake it."

2nd. "In *Pterygotus*, the antennæ," writes Professor Owen, "are forcipated members for the prehension of food, as in *Limulus*. The three succeeding pairs of limbs are still less capacitated, through their smaller size and slenderness, for gradatorial movement of the body. They are adapted to rout out of the sand or mud disturbed by the spade-shaped head the objects of food which the front pair is modified to seize. The larger terminal pair of limbs are more decidedly natatory in form than the corresponding lamelligerous pair in *Limulus*."

We infer from the spatulate form of the great pair of swimming-feet and the rounded and elongated body that *Pterygotus* was a fairly active swimmer, and that it did not burrow. In fact, the position of the compound eyes upon the *edge* of the head precludes the idea of its front border being used as a shovel like that of *Limulus*.

[1] The females of *Brachyscelus* are destitute of the inferior pair of antennæ; the male possesses them like other Amphipoda. Spence Bate and Fritz Müller find no trace of them in the young.

The Merostomata present a reiteration of the same well-marked characteristics observable in the Podophthalmia and Edriophthalmia, namely, the division into 'brachyuran' and 'macrouran' forms, which exemplify well the crawling and swimming types of Crustacea, by the soldering together of the body-segments for strength and compactness in the one, and the retention of free movement of the somites in the other.

Besides being used as organs of prehension, it is highly probable that the several species of *Pterygoti*, all of which were furnished with chelate antennæ, were males, and that their office may have related to sexual functions. *Slimonia*, which attains to a very considerable size, has only minute and simple antennæ destitute of chelæ. This is also the case apparently in both *Eurypterus* and *Stylonurus*. These were perhaps the females.

3rd. Professor Owen observes: "*Pterygotus* and *Eurypterus* resemble *Limulus* in the organs of vision, save that the facets of the large lateral compound eyes are less distinct or less conspicuous in the fossil." In answer to this we would refer to Pls. XIII and XIX (and woodcut, p. 56) of this Monograph, and to the descriptions of many specimens with the facetted surfaces of the eyes *well* preserved. Such admirable specimens were not, however, known to the earlier observers.

We close these notes on modern Limulus with an extract from the admirable Memoir of Professor Alphonse Milne-Edwards, already referred to:[1]—

On the Geographical Distribution of Limulus at the Present Day, and its Fossil Predecessors.

Two species of *Limulus* are found living at the present day, namely, *L. moluccanus* and *L. polyphemus*. "One of these, *Limulus polyphemus*, is confined to the north part of the Atlantic Ocean; it is found upon the Mexican Coast in the Antilles, and upon the East Coast of the United States, especially Florida and Carolina; but it is not known elsewhere, and in the adjacent regions it entirely disappears. *Limulus* reappears very far from these parts, namely, in the islands of Molucca and in the seas of China and Japan, where it presents peculiarities which specifically distinguish it from the Mexican *Limulus*, but in reality there is only a very slight difference between them, and it seems to me difficult to admit that they were not derived from one primitive stock. In fact, nature never seems to repeat itself in creation, and it is hardly probable that the organic type from which the *Limulus* of the Jurassic Period was derived, the existing *Limulus* of the Atlantic Ocean, and that of the Pacific, have no existing ties of kindred between them and are the result of three distinct zoological creations. But at present the Isthmus of Panama, the continents of America, the Arctic Sea, and the Cold Southern Ocean render all communications between the *Limuli* of the Atlantic and Asiatic regions impossible. It remains therefore to be explained how the descendants of *Limulus polyphemus* have migrated as far as the seas of Japan and Molucca, where we now find *Limulus longispina*

[1] "Études Anatomiques sur les Limules: Mission Scientifique au Mexique." Paris: 1873, fol. cinquième partie, p. 4.

or *Limulus moluccanus;* or how the descendants of either of these last-named species have found their way into the Gulf of Mexico, or reached the eastern coast of the United States, and there constituted a locally derived race-species known under the name of *Limulus polyphemus*.

"One is led to think that the separation between these local races, permanent varieties, secondary species (it matters not here which we designate them) must have taken place at a time before the continents of the new world had acquired their present configuration, and when the warm waters of the Atlantic mixed with those of the Pacific without passing through the Polar Regions or Southern Ocean. Such intercommunication has not, however, existed since the elevation of the Tertiary Strata, which now occupy the depths of the Gulf of Darien, and which extend on the south-east as far as the Banks of New Granada in the Pacific Ocean. The conclusion is that the common ancestors of the American and Asiatic *Limulus* must have been connected *before the Tertiary Period;* and if we find a great hiatus between these animals and those of the Jurassic Period, the remains of which are preserved in the Lithographic stone of Solenhofen, it is because the marine deposits of the Cretaceous Period now accessible to our investigations contain only deep-sea forms of life; whereas the King-crabs are never found save in the neighbourhood of the coast. It seems probable to me that all the *Limuli* of the present epoch are descendants of the *Limulus* of the Jurassic Period, and that they constitute the derivative or secondary species in place of the primordial form; in fact, that they are multiple creations from one single zoological type."

Sub-order—XIPHOSURA, Gronovan. 1764.

Genus 1.—Neolimulus, *H. Woodward*, 1868.

Gen. Char.—Head-shield more than twice as broad as deep, glabellal portion occupying more than half the entire breadth of the head, genal portion small; 'facial suture' crossing the cheeks obliquely from the postero-lateral angle of the shield to the compound eyes. Larval ocelli two (or four?) in number. Post-cephalic segments free, 8 (perhaps 9 or more) in number, central axis rapidly diminishing from before backwards; telson not known.

Species 1.—NEOLIMULUS FALCATUS:—H. Woodw., 1868. Pl. XXXI, fig. 8; and woodcut, fig. 78, p. 234.

Neolimulus falcatus, *H. Woodw.*, 1868. Geol. Mag., vol. v, p. 1, pl. i, fig. 1.

It was with extreme interest that I obtained from Mr. Robert Slimon in September

1867, the first evidence of the existence of a true Limuloid form of Crustacean from the uppermost Silurian shale of Lanarkshire.

It is hardly possible to estimate too highly the persevering labours of Mr. Robert Slimon and his sons in the investigation of these Lesmahagow deposits, and one is led to reflect what an enormous amount of additional knowledge would result if other local geologists devoted themselves with the same energy to the investigation of the rocks of their own particular district.

Unlike the majority of the Crustacea obtained from these deposits, our present acquisition cannot be classed among the giants of those days, the specimen only measuring five and a half lines in greatest length, and six lines in greatest breadth. It is preserved upon the extreme edge of a piece of shale, so that, unfortunately, the ultimate segment, as I conceive, and the telson or tail-spine are wanting through being cut off by a cleavage-plane. I have allowed the artist to indicate their probable size in dotted lines in the subjoined woodcut (fig. 78), the rest of the figure actually preserved being given in outline.

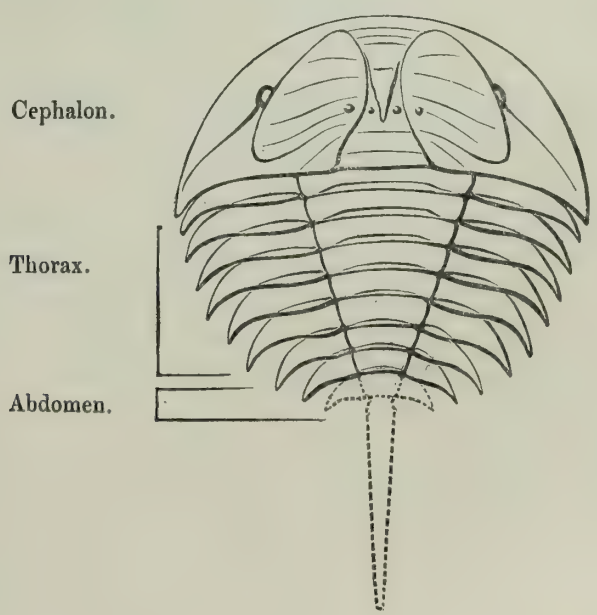


Fig. 78.—*Neolimulus falcatus*, H. Woodw. Upper Silurian, Lesmahagow, Lanarkshire. (Enlarged four times.) Breadth of original six lines; length 5½ lines.

The head-shield is nearly two thirds broader than long, the front margin is semicircular and smooth, and the latero-posterior angles are acute and directed backwards. The posterior border of the head is concave, curving slightly inwards near the centre, and backwards towards the latero-posterior angles.

The glabella is semicircular, and has a tolerably well-defined lateral border separating

it from the cheek, but it approaches to and unites with the border of the head-shield in front. A line (which may correspond with the facial sutnre in Trilobites) passes from the latero-posterior horns of the head-shield, obliquely across the cheeks, and unites with the lateral border of the glabella just where the compound eyes are faintly indicated. A raised **V**-shaped lobe, having its apex directed backwards, marks the centre of the glabella; near its apex four minute dots are visible under the microscope; these are most probably the larval eye-spots or ocelli. From the sides of this **V**-shaped lobe two corresponding lines diverge and unite with the posterior border, whilst the lateral ridges marking the semicircular border of the glabella curve inwards on approaching the posterior border of the head-shield and unite with the median lines near the ocelli. The segments succeeding the head-shield are free, and are strongly trilobed, the ends of the pleuræ are all distinct and falcate. The first six segments are reckoned as thoracic; the abdomen probably consisted of three segments, followed by an ensiform telson, but only two of these segments are preserved. The breadth of the segments diminishes rapidly backwards, the first thoracic measuring five lines across, whilst the sixth is only three lines, but the depth of each segment is nearly uniform. The form which appears to possess the same number of segments is the genus *Hemiaspis* from the Lower Ludlow of Leintwardine, in which we find six thoracic and three abdominal segments; but with this exception our Lanarkshire fossil is a much more Limuloid form than *Hemiaspis*, reminding one strongly of Mr. Baily's *Bellinurus reginæ* from the Irish Coal-measures; from this latter, however, it is also easily separable, both in its general form and also in the non-anchylosed condition of the abdomen. From the genus *Prestwichia* it is also separated by the free condition of *all* its segments.

Not being able to refer the Lanarkshire specimen to any previously described genus of Xiphosura, I propose to name it *Neolimulus falcatus*.[1]

If any one fossil *Limulus* gave promise more than any other to aid the palæontologist in connecting the Xiphosura with the Trilobita ancestrally, it would seem to be the one before us. Its great geological antiquity, as compared even with the *Limuli* of the Coal-measures, naturally leads one to anticipate the discovery of some points indicative of a more generalised type of structure than those of later date. The facial suture in the head-shield, however, seems to be the only approach to a more Trilobitic character than other *Limuli* present.

Of the caudal termination of the body we know nothing, nor are we aware of the form or number of the appendages. Its general facies is certainly Limuloid, not Trilobitic. Nevertheless, the greater freedom of the thoracico-abdominal segments seems clearly to mark it as a more active and natatory type than its adult modern representative, and rather to recall the free-swimming young of *Limulus polyphemus* as it emerges from the egg. (See Pl. XXXIII, fig. 12.)

[1] *νέος*, young, in allusion to its size, and also its early appearance in time (and *limulus*); and *falcatus*, from the sickle-like form of the body-segments.

The Fossil Limuli of the Coal-measures.

Much of the materials here noticed was placed in my hands many years since for examination at that time[1] by Professor Prestwich, F.R.S.; The Broseley Institute; John Anstice, Esq., of Madeley Wood, Wellington, Salop; Mr. E. J. Hollier, of Dudley; Mr. C. Ketley, of Smethwick, near Birmingham; Mr. J. Farie, of Glasgow; Mr. Thomas Birtwell, of Gawthorpe Gardens, Padiham, Lancashire, and by other friends.

After a careful study of the specimens before me in 1866, I ventured to propose their division into two well-marked genera:[2]

(*a*) Those having movable thoracic segments and anchylosed abdominal ones, to be included in the genus *Bellinurus*.

(*b*) Those in which the thoracic and abdominal segments are not divided and in which the former appear to be anchylosed, to be included in the genus *Prestwichia*.

Genus 2.—Bellinurus,[3] *König*. 1820.

Bellinurus, *König*, 1820. Icones Foss. Sect., pl. xviii, fig. 230.
— *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd ser., vol. xi, p. 112.
— *H. Woodw.*, 1867. Quart. Journ. Geol. Soc., vol. xxiii, p. 32.
— *H. Woodw.*, 1872. Geol. Mag., vol. ix, p. 439.
Entomolithus, *Martin*, 1809. Petrificata Derbiensia, Wigan, 4to.
— *Parkinson*, 1811. Organic Remains, &c., vol. iii, p.* 267, pl. xvii, fig. 18.
Limulus, *Buckland*, 1836. Bridgewater Treatise, vol. i, p. 396, and vol. ii, p. 77.
— *Prestwich*, 1840. Geol. Trans., 2nd ser., vol. v.
— *Portlock*, 1843. Report Geol. Londonderry, p. 316.
Bellinurus? *McCoy*, 1855. Pal. Foss. Woodw. Mus.

Gen. Char.—General form suborbicular. Head or cephalic shield semicircular, slightly arched; the central portion (glabella?) prominent and declining towards the circumference, surrounded with a flattened margin, and terminating at its posterior angles in long spines. Thoracic division composed of five free and movable segments which terminate in spines and diminish gradually towards the posterior extremity. Abdomen (or caudal portion) small, with indications of three coalesced somites to which is articulated an elongated spine (*telson*).

Geological horizon.—Upper Old Red Sandstone and Coal-measures.

Geographical distribution.—Kiltorcan, Co. Kilkenny, Ireland; and Coal-measures,

[1] See 'Quart. Journ. Geol. Soc.,' 1867, vol. xxiii, p. 31.

[2] Op. cit., p. 32.

[3] Etym.—Βελος, a dart; οὐρὰ, a tail.

Queen's Co., Ireland; Coalbrook Dale, Shropshire; Dudley, Staffordshire; near Mansfield, Nottingham; Kilmaurs, Scotland.

The generic term *Bellinurus* was applied by König, in 1820, to a peculiar Crustacean from the Coal-measures, figured and named by him *Bellinurus bellulus*;[1] previous to this Martin[2] gave a figure and short description of this species, which he called *Entomolithus monoculites*? (*lunatus*), including it with *Trilobites* under the same generic term of *Entomolithus*, a name which would therefore, according to the rules of nomenclature, be inadmissible. Parkinson[3] figures a similar fossil from Ironstone found in the Coal-measures of Dudley, which he includes with the *Trilobites*, stating at the same time that it appeared to be identical with that described by Martin. The same species is figured and noticed by Dr. Buckland under the name of *Limulus trilobitoides*,[4] and afterwards by Prof. Prestwich, in his paper on the Geology of Coalbrook Dale, who adopts the same name, giving a figure of this and other species belonging to the genus, from the Ironstone found in the Coal-measures of Coalbrook Dale.[5] Lastly, General Portlock figures a specimen said to be from Carboniferous shale (most probably, however, Coal-measures), Maghera, Co. Derry, which he doubtfully refers to the same species.[6]

Professor Morris, in his 'Catalogue of British Fossils,' ed. 2, 1854, cites all the above authorities, except Parkinson, referring the same species to *Limulus trilobitoides*, Buckland.

In a paper read by Mr. William Hellier Baily, F.L.S., before the Geological Society of Dublin,[7] a description was given of a specimen (the only one then obtained) from Bilboa Colliery, Queen's County, discovered by Mr. G. H. Kinahan, M.R.I.A., of the Geological Survey of Ireland, in *débris* derived from the three-foot bed of shale immediately over the coal No. III of the section, Castlecomer district. The accompanying fossils in the same bed of shale were a few scattered plant-remains and numerous small bivalve *Unio*-like shells (probably *Myacites*), and others of a mytiloid form, which may be referred to *Myalina*. In this paper some remarks were offered on the allied species from Coalbrook Dale, which had been included with it in the genus *Limulus*, and it was proposed by Mr. Baily, from the characteristic differences they presented and their supposed greater affinity with the *Trilobites*, to remove all these Coal-measure Crustacea from that genus, and group them in a new one, under the name of *Steropis*.

Since then, Mr. Baily, having obtained more complete specimens from Bilboa Colliery, was confirmed in his views with regard to the advisability of separating them from

[1] 'Icones Fossilium Sectiles,' by C. König, 1820, pl. xviii, fig. 230.

[2] 'Petrificata Derbiensia,' 1809, pl. xlv, fig. 4.

[3] 'Organic Remains,' 1811, vol. iii, p. 274, pl. xvii, fig. 18.

[4] 'Bridgewater Treatise,' 1836, p. 396, vol. i, and vol. ii, p. 77, t. xlvi, fig. 3.

[5] 'Trans. Geol. Soc. Lond.,' ser. ii, 1840, vol. v, pl. xli, fig. 8.

[6] 'Report on Geol. of Londonderry and Tyrone,' 1843, p. 316, pl. xxiv, fig. 11.

[7] 'Journ. Geol. Soc. Dublin,' 1858, vol. viii, p. 89.

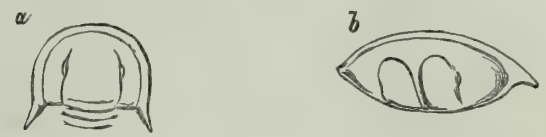
Limulus. Instead, however, of proposing a new generic name, he wisely decided to adopt the appropriate name of *Bellinurus*, which was applied by König to one of the most common species from the West of England.

A very doubtful fossil, from the Lower Silurian, is figured by Professor M'Coy, in Pal. Foss. Woodw. Mus. pl. i E, fig. 22, under the name of "*Bellinurus?*" This may possibly be a phyllopodous head shield.

Species 1.—BELLINURUS KILTORKENSIS:—Baily. MS. (woodcut, fig. 79).

BELLINURUS KILTORKENSIS, *Baily*. Brit. Assoc., Exeter, 1869, Reports, p. 75.

FIG. 79.



The above sketch and the following note concerning this little form of *Bellinurus* was most obligingly furnished me some time since[1] by my friend Mr. William Hellier Baily, F.L.S., Acting Palæontologist to the Geological Survey of Ireland, but has been overlooked until now.

Fragmentary as is the evidence it affords it is nevertheless of the greatest interest, as assisting to fill up the hiatus between *Neolimulus* in the Upper Silurian and *Bellinurus* in the Coal-measures.

It carries back the genus *Bellinurus* to a much more remote period than its congeners.

The fossil remains of *Bellinurus Kiltorkensis*, Baily, consist of a head somewhat distorted (fig. 79 *b*) and another in much better preservation (fig. 79 *a*) with portions of two body-rings united to it.

It closely resembles *Bellinurus reginæ* from the Kilkenny Coal-measures, especially in being provided with a border and spines developed from the posterior angles, as in many of the Trilobites. (*a*.) Carapace measuring half an inch in breadth and $4\frac{1}{2}$ lines in length; cheek spines about 2 lines long. (*b*.) Carapace distorted.

The eyes are about 2 lines apart, and are placed near the anterior margin of the head, being attached to an arched division forming the central portion of the head.

Two portions of the thoracic rings remain attached to the carapace; they appear to terminate in pointed extremities.

Locality.—From the Upper Old Red Sandstone, Kiltorcan, Co. Kilkenny, Ireland.

The specimens are in the Collection of the Geol. Survey of Ireland, Dublin.

[1] July, 1872.

Species 2.—BELLINURUS BELLULUS, König, 1820. Pl. XXXI, figs. 3, *a*, *b* (*not* fig. 3, *c*).

BELLINURUS BELLULUS, *König*, 1820. Icones Foss. Sect., pl. xviii, fig. 230.
— — *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd series, vol. xi, p. 112.
— — *H. Woodw.*, 1872. Geol. Mag., vol. xi, p. 439.
ENTOMOLITHUS (MONOCULUS) LUNATUS, *Martin*, 1809. Pet. Derb., pl. xlv, fig. 4.
— — — *Parkinson*, 1811. Org. Rem., vol. iii, pl. xvii, fig. 18.
LIMULUS TRILOBITOIDES, *Buckl.*, 1836. Bridgew. Treat., pl. 46″, fig. 3.
— — *Prestwich*, 1840. Geol. Trans., 2nd ser., vol. v, pl. xli, fig. 8.
— — ? *Portl.*, 1843. Rep. Geol. Londonderry, pl. xxiv, fig. 11.
BELLINURUS — *H. Woodw.* Trans. Glasgow Geol. Soc., 1866, vol. ii, pl. iii, fig. 10.

There is little to add to the generic description, already given, of this interesting little King-crab, the first which was discovered in the "pennystone" ironstone nodules of the Coal-measures at Dudley and Coalbrook Dale, Shropshire.

The figures in Martin's 'Petrificata Derbiensia' and in Buckland's 'Bridgewater Treatise' convey the impression that the eyes are situated just *within* the arched front of the glabella, but this is not the fact; their true position is distinctly seen in fig. 3 *a*, namely, on the raised lateral margin of the glabella, nearly midway between the front and back of the head-shield. Fig. 3 *b*, is König's original specimen.

B. bellulus approaches most nearly to Baily's species, *B. reginæ* (compare Pl. XXXI, figs. 1 *b*, and 3 *a*), in the greater relative breadth of the cephalon as compared with its depth, in the prominent thickened doublure of the front border of the head, in the strong doubly arched glabella and the long lateral genal spines of the head-shield.

The thoracic segments have a narrow central axis and are strongly trilobed. Each segment terminates laterally in an acutely pointed and recurved spine. The five thoracic segments appear to have been capable of flexure, the divisions or articuli of the axial as well as the lateral portions of the thoracic somites being distinctly marked.

The series of abdominal somites have their margins marked by sutures, but the axial portion of these segments has coalesced. The axis is marked by a prominent tubercle just anterior to the insertion of the caudal spine, which in this species is not quite so long as the rest of the animal, whereas in *B. reginæ* it is just three times the length of the animal's body.

The spine has a strongly marked ridge running down the centre.

In 1866 I figured and described a small but very perfect specimen of this species from the Coal-measures Kilmaurs, near Glasgow, in the 'Transactions of the Glasgow Geological Society' for that year (vol. ii, pl. iii, fig 10). The total length of this specimen

is fifteen lines, of which the head is five lines, the thoracico-abdominal segments four lines, the telson six lines, and the greatest breadth of the head is eleven lines, or more than twice as wide as long.

Localities.—From the Clay-Ironstone of the Coal-measures, Coalbrook Dale; Dudley; Mansfield, near Nottingham; Kilmaurs, Scotland.

Species 3.—BELLINURUS REGINÆ:—Baily, 1853. Pl. XXXI, fig. 1 *a—d.*

BELLINURUS REGINÆ, *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd ser., vol. xi, p. 107, pl. v, figs. 1 A—D.

— — *Baily*, 1863. Quart. Journ. Geol. Soc., 1867, vol. xxiii, pl. i, fig. 1.

Regarding this form Mr. Baily writes:

"In the explanation of Sheet 137 of the Maps of the Geological Survey of Ireland, I have given a short account of the fossils from the Coal-measures of this district, which includes a notice of these remarkable Crustacea from Bilboa. When I visited this locality I was so fortunate as to obtain a very perfect specimen, since named by me *Bellinurus Reginæ* (represented on Pl. XXXI, fig. 1 *a*).

"On another visit a still more perfect specimen (1 *c*) was obtained by the gentleman who accompanied me on that occasion, Mr. John Edge, to whom I am indebted for that and the loan of other specimens, which have materially assisted me in drawing up these descriptions.

"General form broadly ovate, acuminate posteriorly; axis convex. Cephalic shield three and a half times as broad as long, bow-shaped anteriorly, and surrounded by a narrow and flattened margin; the posterior angles produced into long spines, which are directed outwards; central portion, or glabella, smooth and moderately convex, of the same breadth as the axis of the thorax at its junction, but decreasing gradually towards the anterior margin. Eyes central, lunate, attached to these divisions. Thoracic rings (somites) five, the lobes of the first twice as broad as the axis, those of the last rather less in breadth than the axis, the lateral lobes extending in a straight line, each being furrowed and terminating in a spine, the length of which diminishes in regular gradation towards the tail; each of the rings of the axis bears a moderate-sized tubercle. Tail or caudal portion very small, having about three slightly marked divisions on each side, to which is appended or articulated an extremely long spine (*telson*), being three times the length of the other portion of the animal, broad at the base, and tapering gradually to a point.

"The little Crustacean to which I have given the above specific name was found by me in the *débris* of the same coal-pit which yielded the next species; it is in a very perfect condition, and exhibits in a remarkable manner the extravagant development

of its various body-segments into long spines spreading out on each side of the body, and gradually decreasing as they approach the tail, from which proceeds an enormous spine. These characters sufficiently distinguish it from any other species. The head and body in the specimen figured appear to have been a little squeezed together. Another specimen of what I believe to be the same species, obtained by Mr. John Edge, is still more perfect, with the exception of the tail-spine, a portion of which has been broken away; it shows a slight wrinkling or furrowing of the expanded margin of the cephalic shield, as well as the sulcated pleuræ and single tubercle upon each ring of the axis terminating in a larger and more obtuse prominence on the tail. The spine or telson which is attached to this portion exhibits a central longitudinal ridge, having a membranous expansion on each side, similar to that noticed by Parkinson as occurring in the species described by Martin, and which I have referred to *B. bellulus*, König.

"The following are the measurements of fig. 1 *a*:

Length from anterior margin of cephalic shield to end of tail	5 lines	or 10 mill.
Length from anterior to posterior margin of cephalic shield	$2\frac{1}{2}$ „	„ 5 „
Breadth of cephalic shield	$6\frac{1}{2}$ „	„ 13 „
Length of body and tail	$2\frac{1}{2}$ „	„ 5 „
Breadth of body at cephalic shield	4 „	„ 8 „

"Measurement of fig. 1 *c*:

Total length from anterior margin of cephalic shield to point of telson	1 inch 1 line	or 27 mill.
Breadth at widest part of spines	7 lines „	15 „
Breadth of cephalic shield	5 „ „	10 „
Length of telson	10 „ „	20 „ "

Locality.—From Coal-shale, Bilboa Colliery, Queen's County.

Species 4.—BELLINURUS ARCUATUS:—Baily, 1863. Pl. XXXI, figs. 2 *a*, *b*.

BELLINURUS ARCUATUS, *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd series, vol. xi, pl. v, fig. 2 *a*—*c*.

"General form broadly ovate, acuminate posteriorly; axis convex. Cephalic shield semicircular, slightly elevated, declining towards the circumference, and surrounded by a narrow, flattened margin, the central portion or glabella having three ridges extending to about two thirds the breadth of the shield, rounded at their anterior extremity, and forming a double arch, the central portion being broadest at its posterior extremity, the two outermost ridges curving at about half their length towards the very slightly raised semicircular eyes, and continuing beyond the posterior extremity of the shield in two sharp straight spines, which project over the body about one tenth of an inch; the

posterior angles of the cephalic shield are produced into long spines, as in the preceding species, three tenths of an inch in length, slightly curved, and spreading out on either side from the body. Thoracic rings five, which, as in the preceding species, decrease in breadth towards the posterior extremity; the lateral lobes, extending in a straight line, terminate in a short spine, and having an angular furrow, which proceeds to the end, curving at the same angle to the point of each spine. Caudal extremity small, with two or three radiating divisions, to which is appended a spine about equal in length to the head and body.

"This Crustacean differs from the preceding one in having much shorter spiny terminations to the pleuræ and a much shorter tail-spine. The detached head or cephalic shield is more orbicular, and the arched rings proceeding from the middle portion of the head (*glabella*) terminate on each side in short spines, a character not observed in any of the specimens of *B. Reginæ*. I have not succeeded in obtaining good specimens of this species with the body and tail entire; an imperfect one forms the centre of a concretion in the shale, and exhibits a portion of the body with the tail-spine uncompressed, showing distinctly the division of each thoracic ring, with its grooved lateral angles as in the *Trilobites*. In another specimen, which was accidentally relieved from the shale, exposing both sides, the body was found to be doubled back upon the head, like an *Ampyx* or *Trinucleus*. This species is allied to *Bellinurus bellulus*, König, but differs from it in the more orbicular form of the head, the spring termination of the pleuræ, and the greater proportion of the body to the cephalic shield.

"The following are the measurements of fig. 2:

Total length	. . . .	1 inch	or 25 mill.
Total breadth	. . . .	11 lines	„ 22 „
Length of body	. . . .	7 „	„ 15 „
Breadth of cephalic shield	. . .	8 „	„ 17 „
Length of cephalic shield	. . .	4 „	„ 8 „
„ telson, about	. . .	½ inch	„ 12 „ „

Locality.—Found with the previous species at Bilboa Colliery, Queen's County.

Mr. Baily makes the following observations on the beds in which *Bellinurus* occurs:

"As to the question of the freshwater or marine habitat of these Crustacea and their associated fossils, I am inclined to the opinion that the deposits in which they occur were of freshwater or estuary origin, from the abundance of small shells like *Unio*, and others very similar to the freshwater *Mytilus* (*Dreissena*) *polymorphus*, accompanied by the remains of succulent or marshy plants. This opinion corresponds with the observations of Martin and Prestwich. Other theories have been advanced attributing a general marine origin to the coal-beds, in support of which great stress has been laid upon the fact of the occurrence of minute spiral bodies found attached to some of the plant-remains, and formerly referred to *Spirorbis*, a marine genus of Annelida common upon

our shores at the present day, where it is generally attached to sea-weeds, and is well known as *Spirorbis nautiloides*. These little spiral bodies of the Coal-measure plants have, however, been described by Göppert as a fungus under the name of *Gyromyces ammonis*, and are figured by Geinitz in his fine work on the Coal-plants of Saxony. We have here, therefore, an instance of the great caution required in drawing general conclusions from insufficient data, and would rather concur with the remarks offered on the subject at p. 54 of this journal, believing that the Coal-measures afford evidence of having been deposited under both freshwater and marine conditions.

"The discovery of these peculiar Coal-measure Crustacea in Ireland, with associated shells and plants corresponding so remarkably with those found in similar deposits at Coalbrook Dale, in Shropshire, and other parts of the midland counties in England, is a point of great palæontological interest, showing their distribution over a wide area, and indicating the prevalence of the same condition in both counties, although at localities so widely distant."

Species 5.—BELLINURUS KŒNIGIANUS:—H. Woodw., 1872. Pl. XXXI, figs. 3 *c* and 4.

Bellinurus Königianus, *H. Woodw.* Geol. Mag., 1872, vol. ix, pl. x, fig. 8, p. 439.

This new form was obtained from the Dudley Coal-field, and is quite distinct from the type-species *B. bellulus*, König.

The angles of the carapace are blunt, and not produced into long spines, and the five free thoracic somites terminate in obtuse serrations, not in recurved spines, as in *B. bellulus*. The thorax also is relatively broader in proportion to the head; the axis of the body is strongly arched and nearly straight, and does not diminish gradually towards the posterior extremity, as in the other species, although the pleuræ themselves contract to half their breadth from the first to the fifth segment. The raised circular border of the glabella is not so distinctly defined as in *B. bellulus*, but the central axis is more strongly marked. The eyes are not very well seen, but they occupy the same relative position on the margin of the raised glabella, as in *B. bellulus*.

The abdominal division consists, as in the other species, of three coalesced segments, which are, however, only indicated by three marginal serrations.

The tail-spine (telson) is not preserved, but its articulation with the abdomen is strongly marked.

Greatest length of entire body, 9 lines; greatest breadth of head-shield, 1 inch; length of five free thoracic segments, 3 lines; breadth of first free thoracic segment, 10 lines; breadth of fifth free thoracic segment, 5 lines; breadth of central axis of body-segments, $2\frac{1}{2}$ lines.

I have named this species after Mr. Charles König, the original founder of the genus, and for many years the Keeper of the Geological and Mineralogical Collections in the British Museum. The original specimen is preserved in the British Museum, and was obtained by C. Ketley, Esq.

Locality.—From the Clay Iron-stone of the Coal-measures, Dudley Coal-field.

Genus 3.—Prestwichia, *H. Woodward.* 1867.

Limulus, *Prestwich*, 1840. Trans. Geol. Soc., 2nd ser., vol. v.
Bellinurus, *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd series, vol. xi, p. 113.
Prestwichia, *H. Woodw.*, 1867. Quart. Journ. Geol. Soc., vol. xxiii, p. 32.

This genus was proposed by me, in November, 1866, to include certain forms, first noticed by Professor Prestwich from the Coal-measures of Coalbrook Dale, found in nodules of clay-ironstone (called "pennystone"), which have long been known to yield organic remains, such as the cones of *Lepidodendron* (*Lepidostrobi*), the leaves of *Alethopteris*, *Neuropteris*, and *Cyclopteris*, and more rarely the remains of Arachnida (*Etophrynus Prestvicii*), and Crustacea.

Gen. Char.—*Limuli* having a more or less elliptical head-shield, bearing the eyes upon the lateral margins of the glabella; the lateral borders developed into genal spines; the thoracico-abdominal series being apparently united together into one buckler to which the short telson was articulated: central axis of body-segments narrow.

Distribution.—Coal-measures, Airdrie; Padiham, Lancashire; Coalbrook Dale, Shropshire; Dudley; Nottingham.

Species 1.—PRESTWICHIA ANTHRAX, *H. Woodw.* Pl. XXXI, figs. 6 and 6 *a*.

Limulus anthrax, *Prestwich*, 1840. Trans. Geol. Soc., 2nd ser., vol. v, pl. xli, figs. 1—4.
Bellinurus anthrax, *Baily*, 1863. Ann. and Mag. Nat. Hist., 3rd ser., vol. xi, p. 113.
Prestwichia anthrax, *H. Woodw.*, 1867. Quart. Journ. Geol. Soc., vol. xxiii, p. 32, pl. i, fig. 2.

This characteristic species well illustrates the coalescence of the segments of the posterior buckler, which peculiarity I ventured to suggest as a distinguishing mark between the *Bellinuri* and the *Prestwichiæ*. Whilst fully admitting that a knowledge of the complete animal (which, unfortunately, we do not possess), might materially tend to modify our classification of these ancient King-crabs, yet, nevertheless, the palæontologist

is glad to seize upon any such salient point of structure which may present itself in these fossil forms ; and, though it may appear trivial, we may fairly accept it, under reservation, until better specimens afford a clearer insight into their anatomical details.

This species and the next following (*P. rotundata*) were first figured and noticed (though not described) by Mr. Prestwich in his celebrated " Memoir on the Geology of Coalbrook Dale," published in the 'Transactions of the Geological Society' for 1840. Fragmentary remains have since been obtained from Airdrie, Dudley, and from Mansfield, in the neighbourhood of Nottingham.

It is at once readily distinguished from the other Coal-measure *Limuli* by the more outward direction of the genal spines of the head, giving a curious pointed lateral extension to the shield. The hinder border of the cephalon also curves upwards and outwards, so that the cheek-spines seem to spring from the centre of each side of the head, instead of from the postero-lateral border.

The frontal doublure is strongly marked, as in *Bellinurus reginæ*. The details of the eyes and ocelli cannot be well made out, but from the detached head (Pl. XXXI, fig. 6 *a*), one is led to conclude that the glabellal border was marked by a doubly arched front, as in the *Bellinuri*. The back of the head-shield at its articulation with the axis of the thoracic somites is marked by three prominent spines directed backwards. The thoracico-abdominal somites are coalesced, and form a heart-shaped post-cephalic buckler. The border on either hand is marked by six remarkably long slender recurved spines, those of the thoracic somites being as much as seven lines in length. The telson is seven lines long, but it evidently went *beyond* the circumference of the Clay-ironstone nodule (in which it is embedded) into the shale, and its extremity is therefore lost. The narrow but strongly marked axis of the hinder shield was apparently ornamented by a single row of tubercles down the centre of the somites. Traces of three long slender-jointed limbs are seen projecting from beneath the head-shield in Professor Prestwich's specimen; this is the only indication of limb-appendages which these Coal-measure specimens afford.

The following are the measurements of Professor Prestwich's specimen (Pl. XXXI, fig. 6) :

Greatest breadth of head-shield to extremities of genal spines .	2½ inches.
„ length of head-shield . . .	9 lines.
„ breadth of thorax	1¼ inch.
„ length of thorax	11 lines.
„ breath of axis of thorax . . .	3 lines.
Length of telson	7 lines.

[Another form of *Limulus* (*Prestwichia Danæ*) from the Coal-measures, of Illinois U.S., has been described by Messrs. Meek and Worthen,[1] for which Mr. Meek has since proposed the generic name of *Euproops*, in allusion to the anterior position of its eyes.[2]

[1] 'Geol. Surv. Illinois,' 1866, vol. ii; 'Paleontology,' p. 395, pl. xxxii, fig. 2.

[2] 'Geol. Mag.,' 1867, vol. iv, p. 320.

This new form is considered by Mr. Meek to be nearer *Prestwichia anthrax* than to *Bellinurus* by reason of its anchylosed segments, but he considers that it differs from the former in the comparatively small and quadrangular form of the glabella.

Having compared Mr. Meek's figures of *Euproops Danæ* with Professor Prestwich's type specimen of *P. anthrax*, I am in a position fully to appreciate Mr. Meek's accurate comparison of *Euproops* with that species. It seems hardly possible to do more than separate them specifically. Of their generic identity I think there can be but little doubt.]

Species 2.—PRESTWICHIA ROTUNDATA:—H. Woodw. Pl. XXXI, fig. 5.

LIMULUS ROTUNDUS, *Prestwich*, 1840. Trans. Geol. Soc., 2nd series, vol. v, pl. xli, figs. 5—7.

PRESTWICHIA ROTUNDATA, *H. Woodw.*, 1867. Trans. Glasgow Geol. Soc., vol. ii, p. 240, pl. iii, fig. 8.

— — *H. Woodw.*, 1867. Quart. Journ. Geol. Soc., vol. xxiii, pl. i, fig. 1, p. 32.

The original specimen of this well-marked form of Palæozoic King-crab is represented by both the intaglio and relievo impressions preserved in a nearly circular nodule of ironstone from Coalbrook Dale in the cabinet of Professor Prestwich, F.R.S. The relievo side is figured on our plate (Pl. XXXI, fig. 5).

Professor Milne-Edwards, who, at the request of Mr. Prestwich, examined this interesting Coal-measure Crustacean at the time of its discovery, considered it to be a distinct species, and he specially directed attention to the curious membrane-like border of the thoracico-abdominal segments which connects them together.

Other specimens have since been submitted to me from Dudley by Messrs. Charles Ketley and E. Hollier; and from Kilmaurs, near Glasgow, by Mr. Farie. These specimens add but little to our knowledge of the species, derived from the original type-specimen, save that the Kilmaurs example has exceedingly elongated genal spines, thus greatly altering the "circular outline" which suggested to Mr. Prestwich the trivial name of *rotundus*.

Mr. Baily writes ('Ann. and Mag. Nat. Hist.,' 1863, 3rd ser., vol. xi, p. 107):—"A species, closely allied, if not identical with *Bellinurus* (*Limulus*) *rotundus*, Prestwich, sp., was also obtained at the same locality which had yielded *B. reginæ* and *B. arcuatus* (Bilboa Colliery, Queen's County), but as it is scarcely perfect enough for description I have preferred referring it, with a doubt, to that species."

The head-shield is almost three times as broad as deep; the outline is nearly semicircular. The front margin of the glabella is arched, and just within its anterior border

are the larval eye-spots; the compound eyes are placed on its raised lateral border. The glabella is divided down the centre for half its length by a raised ridge, which terminates in a blunt spine posteriorly, whilst in front it bifurcates, forming an arched ridge on either side of the mesial line. Two equidistant ridges, nearly two lines apart, also spring from the posterior border on each side of the mesial ridge of the glabella, and unite with and complete the arched ridges in front. Two lesser arches unite the median and the two next lateral ridges, half way up on either hand. The axis of the thoracic somites is narrow; each somite is ornamented on the median line with a single blunt tubercle, a somewhat larger tubercle marks the coalesced and rudimentary abdominal portion. The broad membranous margin of the thoracico-abdominal somites is divided by seven strongly marked spines of nearly equal length, which do not, however, project far beyond the broad membranous margin. The telson is unknown.

The following are the measurements of Professor Prestwich's specimen (Pl. XXXI, fig. 5):

Greatest breadth of head-shield . . .	2 inches.
„ length of head-shield . . .	9 lines.
Length of genal spines[1]	2 „
Greatest breadth of thoracic somites . .	1 inch 7 lines.
„ „ axis of thoracic somites . .	3 lines.
Breadth of thorax at point of union with head-shield .	1 inch.
Length from back of head-shield to point of insertion of the telson	9 lines.
From back of head-shield to edge of membranous border of abdomen	1 inch.

Species 3.—PRESTWICHIA BIRTWELLI:—H. Woodw., 1872. Pl. XXXI, figs. *7a—c*.

Prestwichia Birtwelli, *H. Woodw.* Geol. Mag., 1872, vol. ix, pl. x, figs. 9 and 10, p. 440.

For a knowledge of this small but well-marked and very characteristic species of Coal *Limulus* I am indebted to the kindness of Mr. Thomas Birtwell, of Gawthorpe Gardens, Padiham, Lancashire, who obtained it from the Coal-measures at the Cornfield Pit on the south bank of the River Calder, near Padiham. It was from this pit that the small fossil Arachnide, *Architarbus subovalis*, H. Woodw.,[2] was obtained by Mr. Birtwell.

[1] Length of genal spine in specimen from Kilmaurs 7 lines.

[2] See 'Geol. Mag.,' 1872, vol. ix, p. 385, pl. ix, figs. 1 *a*, *b*.

This new species, of which there are two examples, both figured in our Pl. XXXI, figs. 7 *a*, *b*, exhibits the most complete anchylosis and obliteration of the divisions of its body-segments of any of the Coal *Limuli*. The entire body measures 8 lines in length, and 8 in greatest breadth; of this the head-shield measures 4 lines in length, and 8 in breadth; the anterior (thoracic) part of the post-cephalic shield is 6 lines broad, diminishing to 2 lines near the posterior (abdominal) part; length of the thoracico-abdominal somites 4 lines. The telson measured 4 lines in length. The head-shield is very tumid, the posterior genal angles are not produced; the glabella is divided down the centre by a slender ridge; its front border (as in most other species) forms two arches, between which and in front of the head-shield, the larval eye-spots are seen; the small compound eyes are placed midway upon the lateral border of the glabella.

The divisions of the thoracico-abdominal segments are only faintly indicated along the central axis of the body; the margin does not show the usual serrations or spines, as in the other species; but the number of segments appears to have been the same. The coalesced abdominal segments were marked by a very prominent spine or tubercle, the top of which has, however, been broken off.

I have named this species *Prestwichia Birtwelli*, after its discoverer, Mr. Thomas Birtwell, in whose collection the specimens are preserved.

Genus 4.—Cyclus, *De Koninck*. 1841.

Cyclus, *De Koninck*, 1841. Descript. Animaux Foss., p. 591.
— *Salter and H. Woodw.*, 1865. Cat. and Chart Foss. Crust., p. 17.
— *H. Woodw.*, 1868. Brit. Assoc. Rep. Norwich, p. 72.
— *H. Woodw.*, 1870. Geol. Mag., vol. vii, p. 554.
Agnostus, *Phillips*, 1836. Geol. Yorkshire, vol. ii, p. 240.

In my fourth Report to the British Association (1868) I described, among other Crustacea, two species belonging to the genus *Cyclus*, one of which still remains unique. Since that date I have, by the kindness of Professor T. Rupert Jones, F.R.S., received a number of specimens of this genus, collected by Professor Harkness, F.R.S., Mr. Joseph Wright, F.G.S., of Belfast, and Mr. J. H. Burrow, of Settle, Yorkshire; from the Carboniferous Limestone, which I described in the 'Geological Magazine' for 1870, p. 554.

Prof. de Koninck, of Liége, the founder of the genus *Cyclus*, has made the following remarks thereon:

"There is no doubt this animal should be ranged with the Crustacea, and in Milne-Edwards's order *Trilobita abnormalia* and *Battoidea*, near to *Agnostus*."

M. de Koninck also considered it probable that the body of *Cyclus* was soft and very contractile, that it was a parasite, and that the two tubercles which we have called

eyes really covered those organs; and further, that the ribbed border protected the feet when the animal was in repose.

We must differ from M. de Koninck in referring this form to the Trilobita. If truly an adult, it must be placed near *Apus* with the other shield-bearing Phyllopoda. If a larval form, it may have been the early stage of *Prestwichia* or some other of the Coal-measure *Limulidæ*. Nor do we think it in the least probable that the shield of *Cyclus radialis* was flexible or contractile, its original segments being completely soldered together into one piece.

If we except *Cyclus Rankini* (Pl. XXXII, fig. 42), which may have been chitinous in its substance like the modern *Limulus*, the other species seem to have had a firm calcareous covering like the test of *Phillipsia* and *Brachymetopus*, found associated with them in the same beds of Carboniferous Limestone in Yorkshire, Ireland, and Belgium.

Species 1.—CYCLUS BILOBATUS:—H. Woodw., 1870. Pl. XXXII, fig. 45 *a*, *b*.

CYCLUS BILOBATUS, *H. Woodw.*, 1870. Geol. Mag., vol. vii, p. 554, pl. xxiii, figs. 3, 3 *a*.
— — *H. Woodw.*, 1873. Brit. Assoc., 7th Report on Fossil Crustacea, p. 304.

This specimen is from Settle, in Yorkshire, and was collected by Mr. J. H. Burrow. Its greatest length is 3 lines. Viewed in profile it is nearly hemispherical (see fig. 45 *b*), its greatest elevation being $1\frac{1}{2}$ line. In general form it reminds us strongly of the dorsal aspect of certain Coleopterous Insects of the genus *Coccinella* or *Cassida*, the elytra being represented by the two large smooth posterior lobes of the shield, with their dividing ridge, and the head and thorax by the anterior third. The border is not flattened and curved outwards in this species, as in *C. radialis* and some others, but is bent downwards and terminates abruptly at the same angle as the rest of the carapace (see fig. 45 *b*). The frontal margin was probably divided into six parts, but it is only imperfectly preserved.

The anterior part of the carapace or buckler is divided transversely from the posterior and larger portion by what, for convenience, we may call "the cervical furrow," whilst a median or "dorsal furrow," divides it down the centre for about one fourth of its entire length, thus separating the anterior parts into two equal lobes; here the median furrow diverges right and left in a crescent-shaped curve, and unites with the cervical furrow, leaving a small elevated median area (cardiac region?), which contracts rapidly backwards and is then prolonged as a narrow dorsal ridge—dividing the two

elytra-like lobes, to the posterior border. The anterior and expanded end of this dorsal ridge is ornamented on either side, at its union with the cervical furrow, by two small crescent-shaped lobes.

The surface of the carapace is everywhere smooth and devoid alike of tubercles and puncta.

Species 2.—CYCLUS TOROSUS :—H. Woodw., 1870. Woodcut, fig. 80, *a*, *b*.

Cyclus torosus, *H. Woodw.*, 1870. Geol. Mag., vol. vii, p. 555, pl. xxiii, figs, 4 and 4 *a*.

— — . *H. Woodw.*, 1873. Brit. Assoc. Reports, 7th Report on Fossil Crustacea, p. 304.

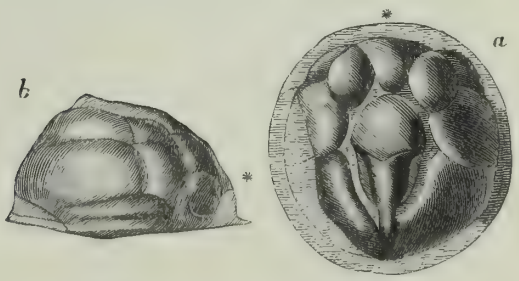


Fig. 80.—*Cyclus torosus*, H. Woodw.
a, dorsal aspect; *b*, profile; * indicates the anterior border of shield.

The buckler in this species is nearly circular, and is 4 lines in diameter. Its dorsal line (viewed in profile) is very tumid, and is elevated 2 lines above its border (see fig. 80, *b*). The cervical furrow divides the carapace transversely into two nearly equal parts (in this respect offering a marked contrast to *C. bilobatus*); the anterior moiety is divided into eight lobes, and the posterior into three. A narrow, slightly flattened border appears to have nearly, if not quite, surrounded the shield.[1]

In front of the carapace is a median, somewhat triangular lobe, having its rounded apex directed backwards; this is flanked on either side by two nearly round lobes, two placed subcentrally and two near each latero-anterior border. Uniting these five anterior lobes with the cervical furrow are two lateral five-angled lobes and a central seven angled (cardiac ?) lobe or area. Behind the cervical furrow a dorsal ridge, of marked elevation, divides the posterior half of the carapace into two rounded lobes, which nearly unite behind—being only separated by a narrow dorsal ridge—but are widely separated in front, not only by the interposition of the dorsal ridge—which expands like the head of a pillar before reaching the cervical furrow—but also by the intercalation of two narrow lobes or ridges on either side of the expanded dorsal ridge. The even contour of

[1] Several of these forms may have been destitute of a rim in front (see *Halicyne*, Pl. XXXII, figs. 48 and 49).

the carapace is only markedly interrupted by a greater degree of prominence in the dorsal ridge just where it expands. The lobes are all roundly tumid, and, like the preceding species, almost smooth. *Cyclus torosus* was obtained from the Carboniferous Limestone of Little Island, Cork, by Mr. Joseph Wright, F.G.S.

Species 3.—CYCLUS WRIGHTII:—H. Woodw., 1870. Pl. XXXII, fig. 47 *a*, *b*.

Cyclus Wrightii, *H. Woodw.*, 1870. Geol. Mag., vol. vii, p. 555, pl. xxiii, figs. 5 and 5 *a*.

— — *H. Woodw.*, 1873. Brit. Assoc. Report, 7th Report on Fossil Crustacea, p. 304.

This well-preserved form (which we have named in honour of the discoverer, Mr. Joseph Wright, F.G.S., of Belfast, who has devoted much time and attention to the investigation of the fossils of the Carboniferous Limestone of Ireland) was procured from the Limestone of Little Island, Cork.[1] It is oval in form, being $2\frac{3}{4}$ lines in length, 2 lines in breadth, and 2 lines in height. *Cyclus Wrightii*, like *C. bilobatus*, has a mimetic resemblance to a Coleopterous Insect, but the disproportion between the anterior and posterior divisions of the carapace is even greater than in *C. bilobatus*, the anterior part forming one fifth of the entire length. A narrow, flattened border encircles four fifths of the carapace, the anterior fifth apparently terminating abruptly at the margin without any border. The dorsal ridge is prominent and broad, and extends from the anterior to the posterior border, commencing as a narrow ridge behind. It spreads out into two successive rounded expansions, and again contracts somewhat before reaching the cervical furrow, in front of which it again becomes much wider, then contracting slowly towards the front. A somewhat triangular lobe flanks each side of this dorsal line in front, whilst two nearly round lobes are placed, one on either side of it, behind the cervical furrow. Nearer the latero-anterior margin two other rounded lobes are formed, one on either side, by a branch of the cervical furrow.

The two great latero-posterior lobes of the buckler have a single corrugated ridge, commencing very faintly at the posterior dorsal line, and running forward and curving around the sides of the carapace, and becoming more strongly marked near the cervical furrow.

The surface is smooth or slightly and very finely granulated.

[1] Another specimen, obtained by Professor Harkness, F.R.S., from the Carboniferous Limestone of Keisley, near Appleby, Westmoreland, appears to be referable to this species, but the intractable nature of the matrix renders it impossible for me to work it out satisfactorily (see Prof. Harkness's paper, 'Quart. Journ. Geol. Soc.,' 1865, vol. xxi, p. 243, &c.).

Species 4.—CYCLUS HARKNESSI:—H. Woodw., 1870. Pl. XXXII, fig. 44 *a*, *b*.

CYCLUS HARKNESSI, *H. Woodw.*, 1870. Geol. Mag., vol. vii, p. 556, woodcut; and pl. xxiii, figs. 6 and 6 *a*.
— — *H. Woodw.*, 1873. Brit. Assoc. Report, p. 304.

This elegant form approaches most nearly to *C. radialis*, but the border of the shield appears to be wanting. Its length is $3\frac{1}{2}$ lines, breadth 3 lines, elevation 2 lines. Another specimen measured 5 lines in length, $3\frac{1}{2}$ lines in breadth, and 3 lines in height.

In this species the usual cervical furrow, dividing the anterior from the posterior portion, is indicated by a ridge which commences in the middle of the shield where the raised dorsal line, instead of terminating, diverges into two lateral branches directed obliquely forwards, froming a Y-shaped elevation, from the branches of which the cervical furrow is continued down to the latero-anterior border.

From the margin of the dorsal ridge seven ribs take their rise on either side, and descend the steep border of the buckler towards its rim, where, it is probable, they terminate in rounded extremities as in *Cyclus radialis* (Pl. XXXII, fig. 43 *b*), but the matrix conceals it (see fig. 44 *b*). I have since been so fortunate as to detach a minute portion of matrix from one of the specimens, and have satisfied myself that such is really the case, so that to fig. 44 *b* a margin needs to be added along the basal line, as in the accompanying woodcut (fig. 81). The ribs are interrupted near the crown of the shield by

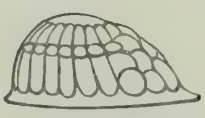


FIG. 81.—Restored profile of *Cyclus Harknessi*, H. Woodw.

two furrows, which encircle the posterior three-fourths of the buckler, so as to break up the ribs near the summit into two sets of tubercles, the inner and upper series being the larger and the lower series the smaller; the surface of the ribs is finely granulated. In front, and partly enclosed by the Y-shaped cervical ridge, and forming the top of the anterior portion of the buckler, are four rounded lobes, with polygonal borders arranged in a diamond-shaped pattern, the posterior one (cardiac?) being the largest of the four.

Placed around and forming a double border to these four lobes are eleven (?) others arranged, firstly, five in one row, and secondly (along the outer margin), six. The surface of the buckler is finely granulated.

The three specimens found belonging to this species, which I have dedicated to my friend Prof. Harkness, F.R.S., are all from the Carboniferous Limestone of Little Island, Cork, from the collection of Mr. Joseph Wright, of Belfast.

Species 5.—CYCLUS RADIALIS :—Phillips, sp., 1836. Pl. XXXII, fig. 43 *a*, *b*.

AGNOSTUS RADIALIS, *Phillips*, 1836. Geol. Yorks., vol. ii, t. xxii, fig. 25.
CYCLUS — *H. Woodw. and Salter*, 1865. Cat. and Chart Foss. Crust., p. 17, fig. 14.
— — *H. Woodw.*, 1868. Brit. Assoc. Report, p. 75, pl. ii, fig. 1.
— — *H. Woodw.*, 1870. Geol. Mag., vol. vii, pl. xxiii, figs. 2 and 2 *a*, p. 557.

I was at first doubtful whether the *Cyclus radialis* of M. de Koninck, from Belgium, really represented the *Agnostus radialis* (?) of Phillips, from the Carboniferous Limestone of Bolland, Yorkshire. I have fortunately been able to see and examine the original specimen of *Cyclus radialis* of M. de Koninck (and Gilbertson's specimens from Bolland, Yorkshire, preserved in the British Museum), and find that it does agree with the figure in Philips's 'Geology of Yorkshire' (vol. ii, t. xxii, fig. 25), but it entirely disagrees with M. de Koninck's *magnified* figure. I have therefore redrawn the Belgian form (see 'Brit. Assoc. Rept.,' 1868, pl. ii, fig. 1). Mr. Hollick in drawing *Cyclus radialis* for the 'Geol. Mag.,' 1870, vol. iii, was good enough to point out that the posterior border of one of M. de Koninck's specimens, from the Carboniferous Limestone of Visé, Belgium, drawn on our Plate XXXII, fig. 43 *a*, *b*, was not broken (as I had supposed and figured it in my Report, op. cit., pl. ii), but was naturally indented upon the posterior border on each side, so as to leave a rudimentary spine at the termination of the dorsal ridge, as seen in our present figure.

Cyclus radialis (fig. 43) is an elegant shield-shaped carapace, 5 lines long by 4 lines in breadth; its general form is hemispherical, with a narrow smooth border (roundly indented behind, so as to leave a rudimentary medial spine in the centre); the shield is divided down its centre by a raised longitudinal (dorsal) ridge, from which radiate seven diverging ribs (transversely wrinkled), whose rounded extremities reach the lateral and posterior border.

The anterior cephalic portion occupies about a quarter of the entire shield, and is ornamented by the spreading out of the raised central ridge, and by two subcentral, rounded prominences, which correspond in position to eyes, but are not facetted. The ribs are ornamented, each with from three to five tubercles irregularly disposed over their surface.

This species (which is the first that was published of this genus) occurs in the Carboniferous Limestone of Little Island, Cork, Bolland and Settle in Yorkshire, and Visé, Belgium.

Species 6.—CYCLUS JONESIANUS:—H. Woodw., 1870. Pl. XXXII, fig. 46 *a*, *b*.

Cyclus Jonesianus, *H. Woodw.*, 1870. Geol. Mag., p. 558, vol. vii, woodcut, figs. 1 and 2.
— — *H. Woodw.*, 1873. Brit. Assoc. Report, p. 304.

Whilst engaged in drawing up this paper Mr. Joseph Wright kindly sent me several additional specimens from Ireland, and amongst them one which is evidently a new form.

The specimen, which measures 3 lines in length, $2\frac{1}{2}$ in breadth, and 2 lines in height, was obtained from the Carboniferous Limestone of Little Island, Cork.

The carapace, which is finely granular all over, is divided in front of the cervical furrow into eight lobes, and behind the same furrow into two lobes, which latter occupy more than half the shield. The two posterior lobes are divided down the mesial line by the dorsal ridge, which at rather more than one third the length stops short. Here two minute depressions occur, and the cervical furrow may be said to branch out right and left, inclosing a central triangular space (cardiac region?), having its base-line directed forward and slightly crenated. In front of this triangular lobe two oblong lobes, united along the median line, occupy about one fourth the length of the carapace (gastric region?), and are bordered by two pairs of lateral and one central, somewhat triangular lobe in front, the whole being probably surrounded by a narrow upturned rim or border.

Cyclus Jonesianus rivals *C. Wrightii* in height, to which form and to *C. bilobatus* it is no doubt closely related.

I have great pleasure in dedicating this species to my kind friend and fellow-labourer in palæontology, Professor T. Rupert Jones, F.R.S., of the Royal Military and Staff Colleges, Sandhurst, to whom I am indebted for much valuable assistance in understanding the hosts of the Bivalved Crustaceans (the *Ostracoda* and *Phyllopoda*), to the fossil forms of which he has devoted so many years of patient, ardent, and successful research.

Species 7.—CYCLUS RANKINI:—H. Woodw., 1868. Pl. XXXII, fig. 42.

Cyclus Rankini, *H. Woodw.*, 1868. Brit. Assoc. Report, p. 72, pl. ii, fig. 2.
— — *H. Woodw.*, 1870. Geol. Mag., vol. vii, pl. xxiii, fig. 1, p. 558.

I first drew attention to this remarkable form at the Meeting of the British Association at Norwich, in 1868.

This new form of *Cyclus*, discovered by Dr. Rankin, of Carluke, in the Carboniferous Shales of that place, is most remarkable in appearance, and far more like a parasitical or

larval form of Crustacean than is the *Cyclus radialis*, which certainly possessed a hard calcareous test. A comparison of the two, however, leaves no doubt in my mind in referring them both to the same genus.

The shield is about 4 lines in diameter, and conveys the idea of an extremely thin test, flattened out on the soft shale by pressure. The "eye-spots" occupy the same relative position as in *C. radialis;* but the divisions which represent the costæ are six, not seven, in number in this species, and these anastomose together on the lateral border, and diverge, not from a raised median ridge, but from a broad, **V**-shaped central area (cardiac region ?). One is reminded by this Crustacean of the appearance of *Argulus*, *Bopyrus*, and other recent parasitic forms, and also of the disk-shaped *Discinocaris*, from which, however, it differs in the "eye-spots" and costated shield.

For this new species I propose the name of *Cyclus Rankini*, after its discoverer.

[Halicyne, von Meyer, 1847.

Hermann von Meyer has figured in the 'Palæontographica,' 1847, vol. i, p. 134, a small Crustacean head-shield under the name of *Halicyne agnota*, and a second species under the name *H. laxa*, from the Muschelkalk of Rottweill in Germany. Goldfuss originally figured it as *Olenus serotinus;* afterwards Münster referred it to *Limulus* ('Beitrage,' 1841, Bd. i, t. v, f. 1).

To both these conclusions von Meyer demurs; to *Limulus* because no eyes are visible, and to the *Trilobita* because none are found in rocks younger than the Carboniferous formation.

The form of this head-shield is extremely like that of *Agnostus;* but the *Agnostidæ* are confined to the Lower Silurian strata, between which and the Trias are the long intervening series of the Upper Silurian, the Devonian, Carboniferous, and Permian formations. At the date of my report (1868) I was inclined to place *Halicyne* with *Bunodes*, *Hemiaspis*, &c., among the aberrant forms of the *Limulidæ*, being under the impression that it was only a part of a Crustacean, probably a head-shield. Having now the advantage of a large series of Carboniferous *Cycli* with which to compare it, I feel no longer any doubt about placing it with *Cyclus*, that being the older name.]

INDEX.

PAGE

Agassiz, Prof. 9, 33, 39, 87, 94, 182
Anatomy of *Limulus polyphemus* 186
„ „ "*Digestive system*" 201
„ „ "*Generative system*" 207
„ „ "*Muscular system*" 186
„ „ "*Nervous system*" 192
„ „ "*Sanguiferous system*" 203
Armstrong, Mr. J. 180
Arrangement of the segments or body-rings... 4, 5
Arthropleura 163, 171
Aymestry Rocks 93

Baily, Mr. W. H...149, 182, 237, 238, 240, 242, 246
Banks, Mr. R. 79, 96, 144
Bellinurus, Genus 236
Bellinurus arcuatus 241
„ *bellulus* 239
„ *Kiltorkensis* 238
„ *Kœnigianus* 243
„ *reginæ* 240
Bibliography of the Merostomata 21
Body-rings or segments, nomenclature of..... 4, 5
Brodie, Rev. P. B. 100, 161
Buckland, Rev. Dr..... 237

Carruthers, Mr. W. 167, 168
Classification of the Merostomata 8
Coal-measures, Fossil Limuli of 236
Cyclus, Genus..... 248
Cyclus bilobatus 249
„ *Harknessi* 252
„ *Jonesianus* 254
„ *radialis* 253
„ *Rankini* 254
„ *torosus*..... 250
„ *Wrightii*..... 251

PAGE

Dana, Prof. J. D. 3, 9, 230
D'Eichwald, Dr. 177
Dekay, Dr. J. E..... 132
De Koninck, Prof. 248, 249, 253
"Digestive system" of *Limulus polyphemus*... 201
Discovery of Fossils in the uppermost Silurian Rocks of Lesmahago 47
Distribution of recent Limulus, geographical 232
Divisions of the body of Crustaceans 3
Dohrn, Dr. Anton 195, 216

Embryology of *Limulus polyphemus* 213
Etheridge, Mr. R., junr. 199
Eurypterida, Sub-order..... 9, 10, 33
"*Eurypterus* ? (*Arthropleura*) *ferox*" 171
" „ ? „ *mammatus*"... 163
Eurypterus, Genus 132
Eurypterus abbreviatus 148
„ *acuminatus* 146
„ *Brewsteri* 151
„ *Brodiei* 161
„ *Hibernicus* 148
„ *lanceolatus* 140
„ *linearis* 147
„ *obesus* 160
„ *punctatus*..... 153
„ *pygmæus* 144
„ *scorpioides* 152
„ *Scouleri* 133
„ and Xiphosura compared..... 183, 231
Exuviation and replacement of lost appendages 210

Fragments of Eurypterus 168
Fossil Limuli of the Coal-measures 236
„ derivatives of Limulus 232

PAGE

Geikie, Prof. Archibald 45, 51
"Generative system" of *Limulus polyphemus* 207
Geographical distribution of Limulus at the present day 232
Geographical distribution of Merostomata... 11—19
Geological range of Merostomata ..... 11—19
Geology of Lesmahagow, Lanarkshire 45

Halicyne 255
Hall, Prof. James..... 9, 33, 35, 40, 106, 141, 182
Hemiaspis, Genus 174
Hemiaspis horridus..... 179
„ *limuloides* 174
„ *Salweyi* 179
„ *speratus*..... 178
Hibbert, Dr. S. 133, 135
Huxley, Prof.... 3, 9, 33, 36, 39, 43, 72, 105, 140, 181, 195, 210

Introduction..... 1, 45, 181

Jardine, Sir W. 92
Jones, Prof. T. Rupert 248, 254

König, Mr. C..... 237, 244

Lesmahagow, Lanarkshire, geology of 45
Limulus, modern, described 185
Limulus polyphemus, anatomy of 186
„ „ embryology of 213
Lloyd, Mr. 191
Lockwood, Rev. S., on King-crab 191, 201, 210, 212
Lower Ludlow Rocks..... 93

McCoy, Prof. 33, 181, 238
Meek, Mr. F. B..... 172, 245
Merostomata, bibliography of the 21
„ classification of the 8
„ geographical distribution of 11—19
„ geological range of..... 11—19
„ Order 9, 10
Meyer, H. von 254
Miller, Hugh 94
Milne-Edwards, Prof. Alphonse 2, 3, 7, 198, 210, 213, 232, 233, 246
Modern Limulus described..... 185
Murchison, Sir R. I. 45, 46
"Muscular system" of *Limulus polyphemus*... 186

PAGE

Neolimulus, Genus 233
Neolimulus falcatus 233
"Nervous system" of *Limulus polyphemus* ... 192
Nieszkowski, Dr. J. 39, 133, 176
Nomenclature of joints in limbs of Crustacea 6
„ of segments or body-rings 4, 5
Note on some supposed fragments of a Eurypterus 168
Number of body-segments 2, 6

Observations on Palæozoic strata, near Lesmahagow..... 46
Old Red Sandstone, description of the 49
„ „ Cradley 102
„ „ Pontrilas and Monmouth Cap 103
„ „ Trimpley 102
Owen, Prof., on American King-crab... 183, 186—209, 216, 219, 224, 228, 231

Packard, Dr. A. S., jun..... 195, 213
Page, Prof. David 39, 121, 129
Passage-beds 96
„ at Ledbury, Herefordshire 99
„ at Linley, Salop 101
„ at Ludlow 97
„ of the Woolhope district..... 100
Peach, Mr. B. N. 51
Portlock, General 237
Powrie, Mr. J. 199
Prestwich, Prof. 237, 244
Prestwichia, Genus 244
Prestwichia anthrax 244
„ *Birtwelli*..... 247
„ *rotundata* 246
Pterygotus, Genus 33
Pterygotus anglicus 33
„ *arcuatus* 88
„ *Banksii*..... 72
„ *bilobus* 54
„ „ var. *α, inornatus* 55
„ „ var. *β, crassus* 62
„ „ var. *γ, perornatus* 63
„ „ var. *δ, acidens* 68
„ *gigas*..... 79
„ *ludensis*..... 76
„ *minor* 35

PAGE

Pterygotus problematicus 85
„ *raniceps* 71
„ (?) *stylops* 91
„ *taurinus* 76
„ remains of, in West of England ... 71

Ramsay, Prof. 45, 46
Randall, Mr. J. 101
Rankin, Dr. 254
Relations of the Palæozoic Strata, near Lesmahagow 46
Remains of Pterogotus from the West of England 71
Replacement of lost appendages 210
Roberts, Mr. G. E. 76, 101
Rowlestone section and Cusop beds, near Hay 104

Salter, Mr. J. W. 33, 36, 39, 42, 54, 71, 74, 77, 79, 95, 105, 124, 128, 133, 134, 140, 145, 146 147, 148, 156, 164, 171, 174, 181
"Sanguiferous system" of *Limulus polyphemus* 203
Scouler, Dr. J. 133
Section at the railway tunnel, near Ledbury 100
Section below the base of Old Red Sandstone, Lesmahagow 52
Segments or body-rings 4, 5
Silurian localities in West of England where Fossil Merostomata have been found ... 92
Slimon, Mr. R. 40, 45, 46, 50, 105
Slimonia, Genus 105
Slimonia acuminata 105

PAGE

Spawning of *Limulus polyphemus* 212
Spence Bate, Mr. C. 3, 6, 7, 185
Steinhauer, Rev. H. 168
Strickland, Mr. H. E. 85, 92
Stylonurus, Genus 122
Stylonurus ensiformis 126
„ *Logani* 129
„ *megalops* 124
„ *Powriei* 122
„ *Scoticus* 126
„ *Symondsii* 124
„ telson of 199
Symonds, Rev. W. S. 92

Table showing geological range and geographical distribution of Merostomata 11—19
Telson, compound nature of, in Limulus 198
„ „ of, in Stylonurus... 199

Upper Llandovery Sandstone 92
Upper Ludlow Rocks 94
Upper Silurian Rocks, description of the 47

Vander Hoeven, J. 195, 210

Wenlock Limestone and Shale 92
Westwood, Prof. J. O. 3
Worthen, Mr. A. H. 172, 245

Xiphosura and Eurypterida compared ... 183, 229
„ Sub-Order 9, 10, 182, 233

Zoological position of *Limulus* 229

LIST OF WOODCUTS.

Fig.		page
1.	Walking leg of Decapod	6
2.	Jaw-foot of Pterygotus	6
3.	*Pterygotus problematicus*	24
4.	„ *anglicus* (restored)	27
5.	„ „ section of anterior part of the body	41
6.	*Pterygotus anglicus*, section of posterior part of the body	42
7.	Section of the Upper Silurian and other strata near Lesmahagow	51
8.	Head of *Pterygotus bilobus*, underside	56
8a.	Portion of eye, magnified	56
9.	Ornament on *Pterygotus bilobus*	57
10.	Organs detached from head of *Pt. bilobus*	58
11.	Endognath of *Pterygotus bilobus*	59
12.	Operculum of *Pt. bilobus*, var. *a*	61
13.	Thoracic plate of *Pt. bilobus*, var. δ	69
14.	*Pterygotus taurinus*	75
15.	Ectognath of *Pterygotus ludensis*	78
16.	Endognath of *Pterygotus ludensis*	78
17.	Head of *Pt. gigas*	81
18.	Metastoma of Pterygotus	84
19.	„ „ *Pt. problematicus*	84
20.	Thoracic plate of *Pt. problematicus*	88
21.	Endognath of *Pterygotus arcuatus*	89
22.	„ „ „	89
23.	Metastoma of *Pterygotus arcuatus*	90
24.	Head of *Pterygotus stylops*	91
25—27.	Crustacean appendages, doubtful	91
28.	Section at Church Hill, Leintwardine	94
29.	Section at railway tunnel, Ledbury	100
30.	Plicæ, greatly magnified (*Slimonia acuminata*)	108
31.	Antenna of *Slimonia acuminata*	109
32.	Endognathary palpus of Slimonia	112
33.	Largest lip-plate of *Slimonia acuminata*	113
34.	Operculum of *Limulus polyphemus*	115
35.	Operculum of *Slimonia acuminata*	116
36.	„ „ inner side	117
37.	„ „	117
38.	„ „ *acuminata*	118
39.	*Stylonurus Logani*	131
40.	*Eurypterus remipes*	132
41.	Head of *Eurypterus Scouleri*	135
42.	Body-rings of *Eurypterus Scouleri*	137
43.	*Eurypterus Scouleri*	139
44.	„ *lanceolatus*	142
45.	„ *Hibernicus*, body segment	150
46.	„ „ endognath of	150
47, 48.	Chela of Crustacean	150
49.	Median appendage	154
50.	Lip-plate of *Eurypterus punctatus*	155
51.	Endognathary palpus of *Eurypterus punctatus*	157
52.	*Eurypterus obesus*	160
53.	„ *Brodiei*	162
54.	„ *mammatus*	164
55.	*Arthropleura armata*	166
56.	*Phytolithus parmatus*	168
57.	*Hippurites gigantea*	169
58.	*Calamites varians*	169
59.	*Equisetites infundibuliformis*	170
60.	„ „	170
61.	„ „ foliage of	170
62.	*Euphoberia ? major*	172
63.	*Arthropleura ferox*	172
64.	*Hemiaspis limuloides*	177
65.	*Pseudoniscus aculeatus*	177
66.	*Exapinurus Schrenkii*	177
67.	*Bunodes lunula*	177

Fig.		page
68.	Head-shield of *Hemiaspis speratus*	178
69.	„ „ *horridus*	179
70.	„ „ *Salweyi*	179
71.	Lip-plate of Pterygotus	180
72.	*Hemiaspis limuloides*	200
73.	Telson of Stylonurus	200
74—77.	Earliest stages in embryology of *Limulus polyphemus*	214
78.	*Neolimulus falcatus*	234
79.	*Bellinurus Kiltorkensis*	238
80.	*Cyclus torosus*, two views of shield	250
81.	„ *Harknessi*, profile of	252

LIST OF PLATES.

PLATE

I. *Pterygotus anglicus* and *Pterygotus minor.*
II. *Pterygotus anglicus.*
III. „ „
IV. „ „
V. „ „
VI. „ „
VII. „ „
VIII. „ „
IX. Recent Crustacea.
X. *Pterygotus bilobus.*
XI. „ „
XII. „ „
XIII. „ „
XIV. „ „
XV. „ „
XVI. „ and *Parka.*
XVII. *Slimonia acuminata.*
XVIII. „ „
XIX. „ „
XX. „ „

PLATE

XXI. *Stylonurus.*
XXII. „ *Scoticus.*
XXIII. „ „
XXIV. „ *Logani* and *Eurypterus mammatus.*
XXV. *Eurypterus Scouleri.*
XXVI. „ „
XXVII. „ „
XXVIII. „ fragments of.
XXIX. „ *scorpioides.*
XXX. „ and *Hemiaspis.*
XXXI. Limuli from the Carboniferous and Silurian formations.
XXXII. Development of Agnostus, Sao, and Trinucleus. Cyclus and Halicyne.
XXXIII. Larval stages of *Limulus polyphemus.*
XXXIV. Anatomy of „ „
XXXV. „ „ „
XXXVI. „ „ „

PLATE XXXI.

SILURIAN AND CARBONIFEROUS CRUSTACEA.

Order—MEROSTOMATA.

Sub-Order—XIPHOSURA.

FIG.

1. *Bellinurus reginæ*, Baily, 1863. (P. 240.) Coal-measures, Queen's County, Ireland. Museum of the Geol. Survey of Ireland, Dublin.

1 *a*, 1 *c*. Specimens drawn of the natural size.

1 *b*. The same greatly enlarged.

1 *d*. One of the thoracic somites enlarged.

2. *Bellinurus arcuatus*, Baily, 1863. (P. 241.) Coal-measures, Queen's County, Ireland. Museum of the Geol. Survey of Ireland, Dublin.

2 *a*. Specimen drawn of the natural size.

2 *b*. A head-shield greatly enlarged.

3. *Bellinurus bellulus*, König, 1820. (P. 239.) Coal-measures, Coalbrook Dale, Shropshire, &c.

3 *a*. The original specimen in the cabinet of Prof. Prestwich, F.R.S. (enlarged).

3 *b*. Specimen originally figured by Buckland, and now in the British Museum.

3 *c*, & 4. *Bellinurus Kœnigianus*, H. Woodw., 1872. (P. 243.) Coal-measures, Dudley Coal-field. Both figures are enlarged. Original specimens in the British Museum.

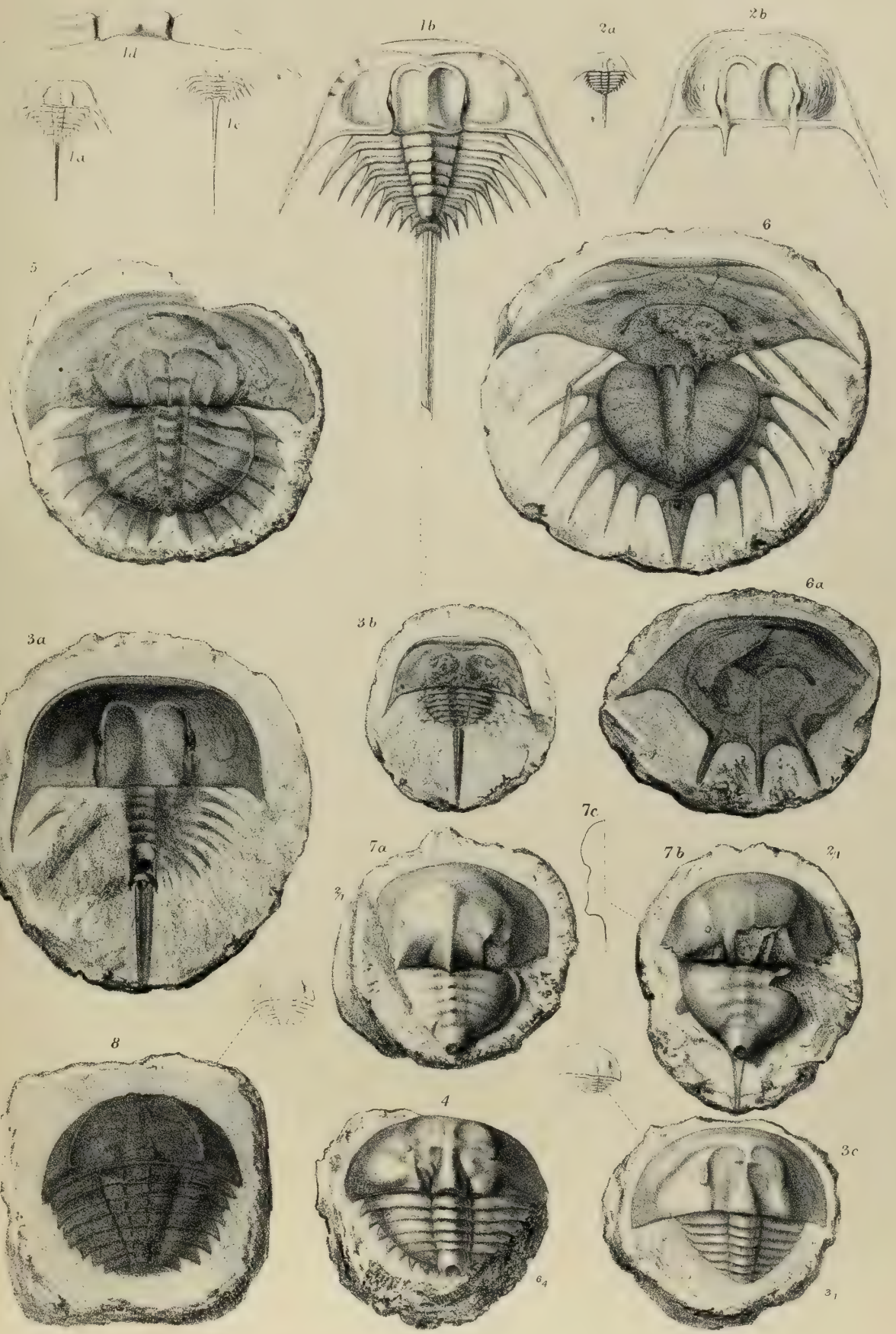
5. *Prestwichia rotundata*, H. Woodw., 1867. (P. 246.) Coal-measures, Coalbrook Dale. (Natural size.) The original specimen in the cabinet of Prof. Prestwich, F.R.S.

6. *Prestwichia anthrax*, H. Woodw., 1867. (P. 244.) Coal-measures, Coalbrook Dale. (Natural size.)

6, & 6 *a*. The original specimens in the cabinet of Prof. Prestwich, F.R.S., &c.

7 *a*, *b*, *c*. *Prestwichia Birtwelli*, H. Woodw., 1872. (P. 247.) Coal-measures, near Padiham, Lancashire. (Enlarged twice the natural size.) 7 *c*, profile. The original specimens in the collection of Mr. Thomas Birtwell, Gawthorpe Gardens, Padiham, Lancashire.

8. *Neolimulus falcatus*, H. Woodw., 1868, enlarged. (P. 233.) Upper Silurian, Lesmahagow, Lanarkshire. The natural size given in outline. The original specimen preserved in the British Museum.



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LIMULI FROM THE CARBONIFEROUS & SILURIAN FORMATIONS

PLATE XXXII.

SILURIAN AND CARBONIFEROUS CRUSTACEA.

FIGS.

1—39. Developmental stages of TRILOBITA (after Barrande).

1—7. *Agnostus bibullatus*, Barr., 'Syst. Silur. de Bohême,' pl. xlix, p. 906, étage C, Skrey, Bohemia.
Fig. 1. Cephalon and pygidium only observable.
2. „ „ and two soldered thoracic somites.
3. „ „ one soldered and one free.
4. „ „ „ and two free.
5 *a*, *b*. „ „ „ thoracic somites (form long).
6. „ „ „ „ (form broad).
7. The free thoracic segments seen enlarged.

8—14. *Agnostus nudus*, Beyr., 'Barr. Syst. Silur. de Bohême,' pl. xlix, p. 903, étage C, Skrey, Bohemia.
Fig. 8. Cephalon and pygidium only observable.
9. „ „ and two soldered thoracic somites.
10. „ „ and one soldered and one free thoracic somites.
11. „ „ and two free thoracic somites.
12 *a*, *b*. „ „ „ „ (form long).
13. „ „ „ „ (form broad).
14. The two free thoracic somites seen enlarged.

15—28. *Sao hirsuta*, Barr., 'Syst. Silur. de Bohême,' pl. vii, étage C, Skrey, Bohemia.
Figs. 15 and 16. Two individuals in which there is no line of separation between the head and the pygidium; in Fig. 15 a slight indication on the axis marks the commencement of the division of the body into somites; the glabella is also marked by a simple fold on the cephalic portion.
Fig. 17. Shows the second stage with three soldered somites; the thorax is indicated (form broad).
18. The third stage. The genal spines and the points of the pleuræ are well seen; four to five soldered somites are indicated.
19. Fifth stage. Thorax longer than head, with three free and three soldered somites (form broad).
20. The same degree of development as Fig. 19 (form long).
21. Broad form, with four free segments and three or four soldered segments.
22. Tenth stage. Form broad; eight free and three soldered segments; the compound eyes are seen at this stage.
23. Twelfth stage. Form broad; ten free and three to four soldered somites; the eyes and ornament on the head are seen.
24. Fourteenth stage. Form long; twelve free and two to four soldered somites; four lobes marked on glabella.
25. Sixteenth stage. Form long; fourteen free and three soldered somites.
26. Eighteenth stage. Form long; sixteen free and three soldered somites; the number of somites is completed at this stage.
27. Twentieth stage. Form long; all the segments of the thorax and pygidium are very distinct; seventeen free somites and two soldered. The ornamentation at this stage assumes all the characters of the adult.
28. View in profile, restored from numerous fragments, showing all the ornamentation of the test. (P. 223.)

29—39. *Trinucleus ornatus*, Sternb., 'Barr. Syst. Silur. de Bohême,' pl. xxx, p. 624, étage D, Trubin.
Fig. 29. Young, with no thoracic segments, and without genal spines.
30. „ „ „ and with „
31. „ one „ without „
32. „ „ „ and with „
33. „ two „ without „
34. „ „ „ and with „
35. „ three „ „ „
36. „ four „ „ „
37. „ five „ without „
38. Adult, one part of the test on the right genal border preserved.
39. „ head-shield without genal spines.

40. *Trinucleus ornatus*, Sternb., 1833. Hypothetical development of the fringe of glabella, after Salter.

41. Fringe of *Trinucleus fimbriatus*, Murch., 1839.
Figs. 40 and 41 illustrate Mr. Salter's paper, 'Quart. Journ. Geol. Soc.,' 1847 (vol. iii, p. 252, woodcuts). (P. 218.)

42. *Cyclus Rankini*, H. Woodw., 1868. (P. 254.) Coal-shales, Carluke, Scotland (diameter 4 lines).

43. — *radialis*, Phillips, sp., 1829. (P. 253.) Carboniferous Limestone, Settle and Bolland, Yorkshire.
a, dorsal aspect; *b*, side-view.

44. — *Harknessi*, H. Woodw., 1870. (P. 252.) Carboniferous Limestone, Little Island, Cork, Ireland.
a, dorsal aspect; *b*, side-view.

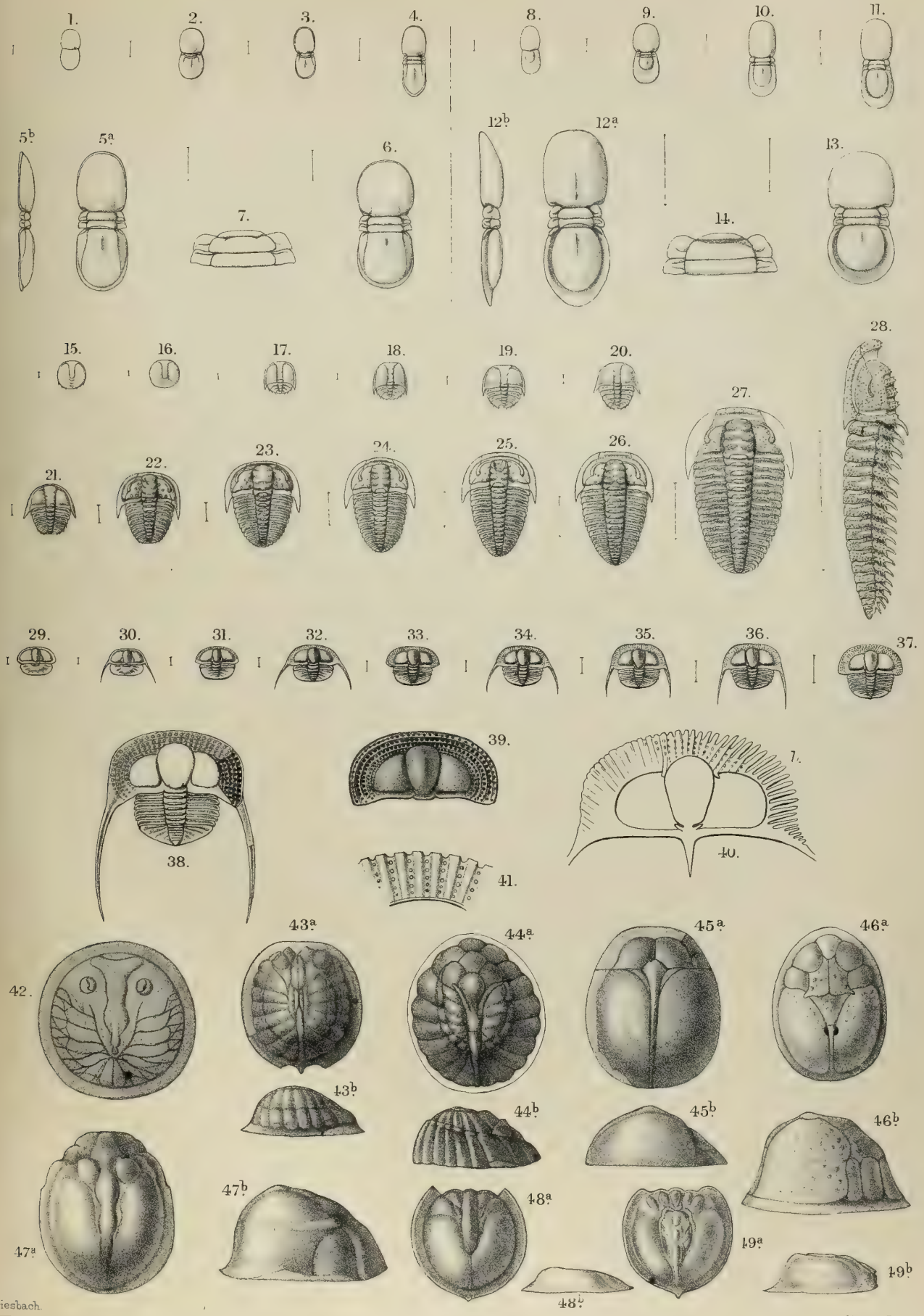
45 — *bilobatus*, H. Woodw., 1870. (P. 249.) Carboniferous Limestone, Settle, Yorkshire.
a, dorsal aspect; *b*, side-view.

46. — *Jonesianus*, H. Woodw., 1870 (P. 254) (magnified four times). Carboniferous Limestone, Little Island, Cork, Ireland.
a, dorsal aspect; *b*, side-view.

47. — *Wrightii*, H. Woodw., 1870. (P. 251.) Carboniferous Limestone, Little Island, Cork, Ireland.
a, dorsal aspect; *b*, side-view.

48. — (*Halicyne*) *laxus*, H. von Meyer, sp. (P. 255.) Muschelkalk, Rottweil, Germany.
a, dorsal aspect; *b*, side-view.

49. — (*Halicyne*) *agnotus*, H. von Meyer, sp. (P. 255.) Muschelkalk, Rottweil, Germany.
a, dorsal aspect; *b*, side-view.



Figs 1–41. DEVELOPMENT OF AGNOSTUS, SAO, AND TRINUCLEUS. *(after Barrande.)*
Figs. 42–47. CYCLUS, CARBONIFEROUS L. Fig 48 & 49. HALICYNE, TRIASSIC.

PLATE XXXIII.

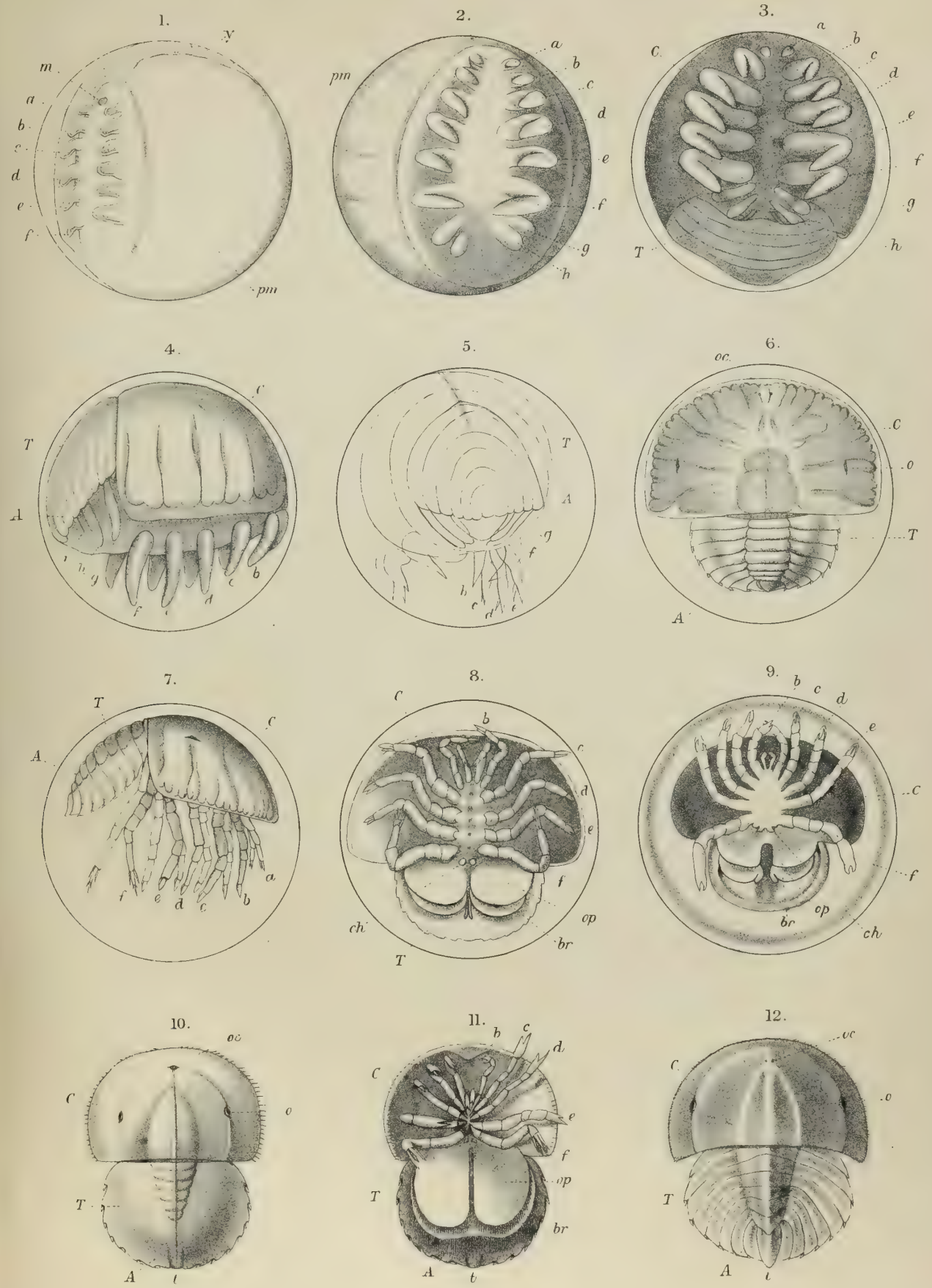
Order—Merostomata.

Sub-Order—Xiphosura.

Larval stages of *Limulus polyphemus*, Latr.

Figs.

1. The embryo enclosed within its two membranous egg-envelopes, the inelastic "chorion," and the inner elastic "protoderm" (*y*). The primitive disc is seen marked off from the main yolk-mass (*p m*), and bearing the mouth (*m*) and the six pairs of finger-shaped, rudimentary cephalic limbs (*a—f*). Copied from Dr. Packard's 'Memoir,' op. cit., pl. [illegible], fig. 13. (P. 215.)
2. The beginning of the "sub-zoëan stage," in which two pairs of thoracic appendages (*g*, *h*) are added to the six pairs seen in Fig. 1, and the appearance of segmentation on the back of the embryo (*p m*). Copied from Packard, pl. iv, fig. 16. (P. 215.)
3. Ventral aspect, and 4. Side-view of embryo. The thoracico-abdominal division (T, A) is now clearly differentiated from the head (C), with the segments well marked. The five (or six?) lobes of the liver indicating five (or six?) cephalic somites (see Fig. 4 *c*), A third pair of thoracic appendages are added (Fig. 4 *i*). Copied from Packard, pl. iv, figs. 19, 19 *a*. (P. 216.)
5. Posterior view of an older individual, showing the thoracico-abdominal segments, the cephalic limbs, and the three pairs of thoracic branchial feet and the dorsal heart. Copied from Packard, pl. iv, fig. 20. (P. 217.)
6. The dorsal aspect; Fig. 7, the side-view or profile; and Fig. 8, the ventral aspect of the same embryo just before hatching; *oc*, the ocelli; *o*, the compound eyes; *ch*, the "chilaria" or "metastoma;" *op*, the opercular plate; *br*, the branchial plate. The other letters correspond with the same parts in previous figures of the earlier stages of the embryo. Copied from Packard, pl. v, figs. 24, 24 *a*, 24 *b*. (P. 218.)
9. Ventral aspect of another embryo somewhat less advanced than Fig. 8 (copied from Dr. Anton Dohrn). The "chorion" is split, and the embryo is seen to revolve within the expanded "protoderm." The letters correspond with those marked on the embryos in earlier stages. (P. 219.)
10. Dorsal aspect; and Fig. 11, ventral aspect of freshly hatched young of *Limulus polyphemus*. Copied from Packard, pl. v, figs. 25 and 25 *a*. (P. 220.)
12. Nearly the same stage as the foregoing (copied from Dr. Anton Dohrn). This is Dohrn's "Trilobitenstadium." (P. 220.)



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LARVAL STAGES OF LIMULUS POLYPHEMUS, LATR.
(after Dohrn & Packard.)

PLATE XXXIV.

Order—MEROSTOMATA.

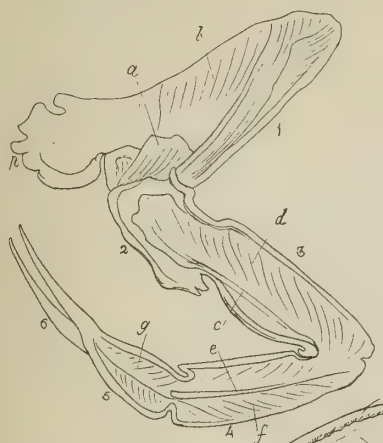
Sub-Order—XIPHOSURA.

Anatomy of *Limulus polyphemus*, Latr. (after Owen). (Pp. 186—209.)

FIGS.

1. Side-view of heart, alimentary canal, and nervous system (seen in a longitudinal section).
   - A. Cephalon ("Cephaletron," Owen).
   - B. Thoracico-abdominal somites coalesced ("Thoracetron," Owen).
   - C. Telson ("base of Pleon," Owen).
   - A′. Under or vaulted surface of cephalon.
   - B″. Rudimentary abdomen ("anal segment of Thoracetron," Owen).
   - I. The compound eye. *a* 1. Ocelli. II. Antennule. III. Antenna. IV. Mandible. V. First maxilla. VI. Second maxilla. [In Fig. 1 the forcipated foot of the maxilliped VII has not been indicated by the artist, but see VII, Fig. 2.] VII. Maxilliped. VIII. Operculum. IX—XIII. The five branchial feet.
   - *b*. Dorsal wall of cephalon. *c*. Ventral wall of cephalon. *d*. Digging border of head-shield. *e*. Holding border of cephalon. *f*. Hinder border of cephalon. *g*. Entering process of thorax. *h*. Entosternon. *i*. Intestine. *m* 1. Levatores thoracetri. *m* 7. Levatores telsoni. *m* 8. Obliqui telsoni. *m* 9. Depressores telsoni. *n a*. Ocellar nerve. *n* A. Ocular nerve. *n* II. Antennular nerve. *n* III. Antennal nerve. *n* IV. Mandibular nerve. *n* V. Premaxillary nerve. *n* VI. Maxillary nerve. *n* VII. Maxillipedal nerve.
2. Section through anterior part of cephalon, showing gastric cavity and buccal orifice with maxillipeds, numbered as in Fig. 1. (Pp. 190, 201, 202.)
3. A detached maxilla showing the articulations and the palpus. (P. 186.)
4. A detached maxilliped (for nomenclature of joints see p. 6, Part I, of this Monograph). (P. 190.)
5. Section of one of the maxillæ to show the muscles. (P. 187.)

Fig 5



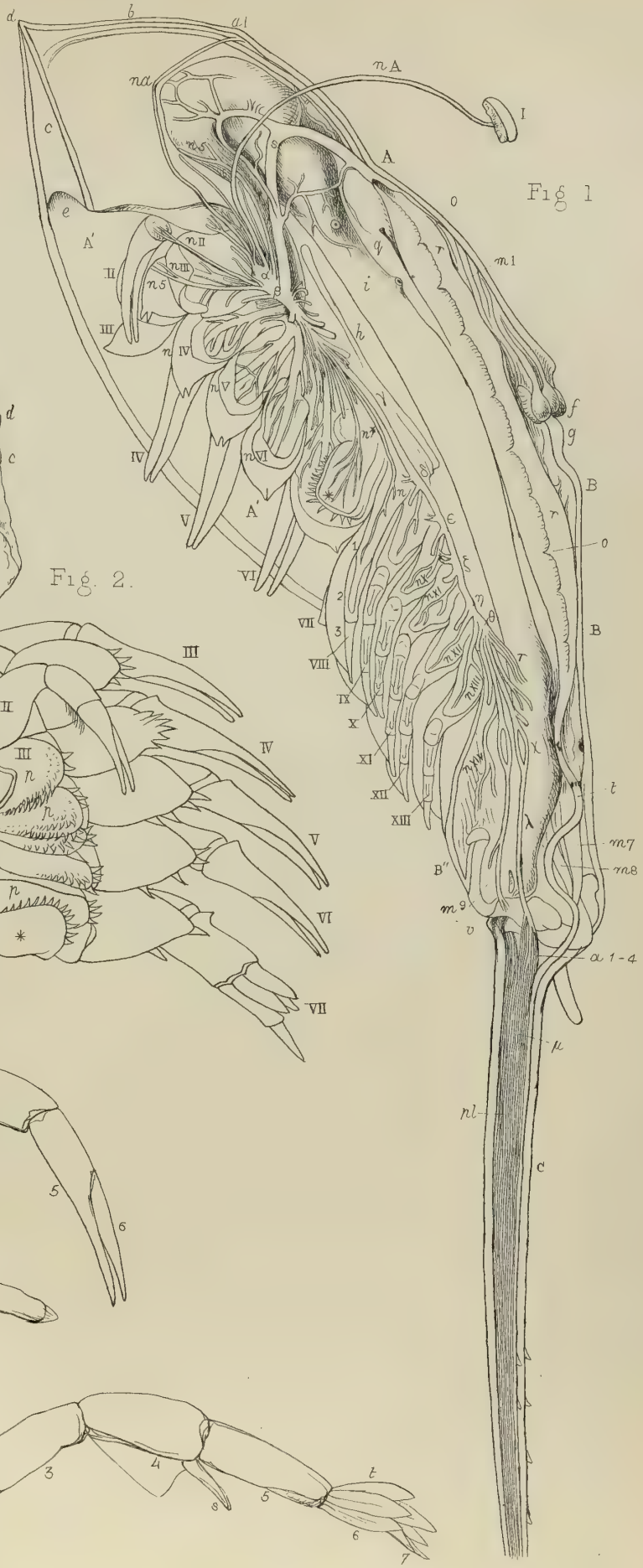


Fig 1

Fig. 2.

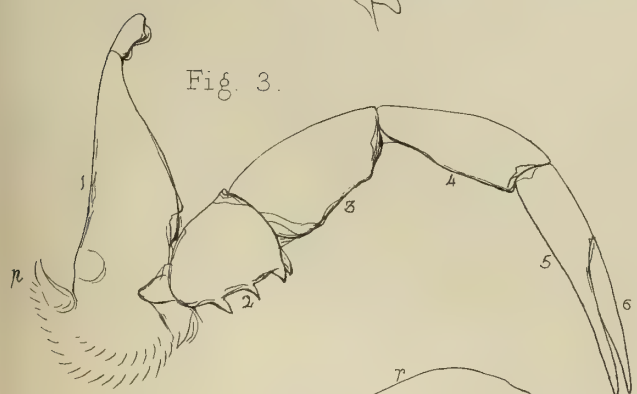


Fig. 3.

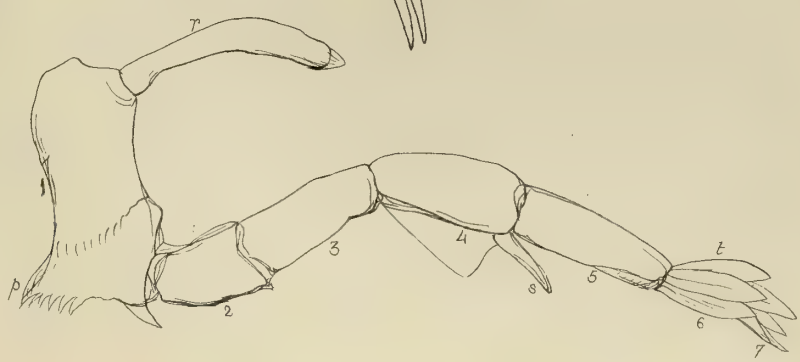


Fig. 4

ANATOMY OF LIMULUS POLYPHEMUS, LATR. (after Owen)

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PLATE XXXV.

Order—MEROSTOMATA.

Sub-Order—XIPHOSURA.

Anatomy of *Limulus polyphemus*, Latr. (after Owen).

FIG.

1. The nervous system, seen from the lower or ventral aspect. (Pp. 192—198.)
   A′. Inferior surface of cephalon. A″. Posterior point of lateral or *yenal* portion of the cephalon. B′. Infero-lateral surface. B″. Infero-median surface of thoracetron (thoracico-abdominal shield). *n* XV. Nerve of anal segment. (The other letters are the same as in Pl. XXXIV.)
2. Compound eye and terminations of ocular nerve, from the dorsal aspect; magnified 6 diameters. (P. 192.)
   d. Dorsal branch and divisions of ocular nerve. *v*. Ventral branch and divisions of ocular nerve.
3. Compound eye of a Trilobite (*Phacops*), magnified 3 diameters.
4. Portion of the same compound eye, magnified 10 diameters.
5. Entosternon and attached parts of muscles; after vander Hoeven. (P. 187.)
6. Chief parts of ovarium, oviducts, and opercular plate (upper or inner surface). (P. 208.)
   m 11. Muscles of operculum. *o*, *o*. Oviducts. *p*. Oviducal outlets. *q*. Postero-median lobe of ovary. *q**. Antero-median lobe of ovary. *q*″. Antero-lateral loops and branches. *q***. Postero-lateral cephalic branches. *r*, *r*. Articular surfaces of opercular plate. 2. Second joint of opercular plate. 3. Third joint. 4. Median appendages of opercular plate.
7. Section of terminal part of oviduct (after vander Hoeven).
   a. Oviduct. *b*. Anterior labium. *c*. Part of opercular plate.
8. Portion of opercular plate with terminations of the sperm-ducts, *p*, *p*; after vande Hoeven. (P. 209.)

Fig. 1.

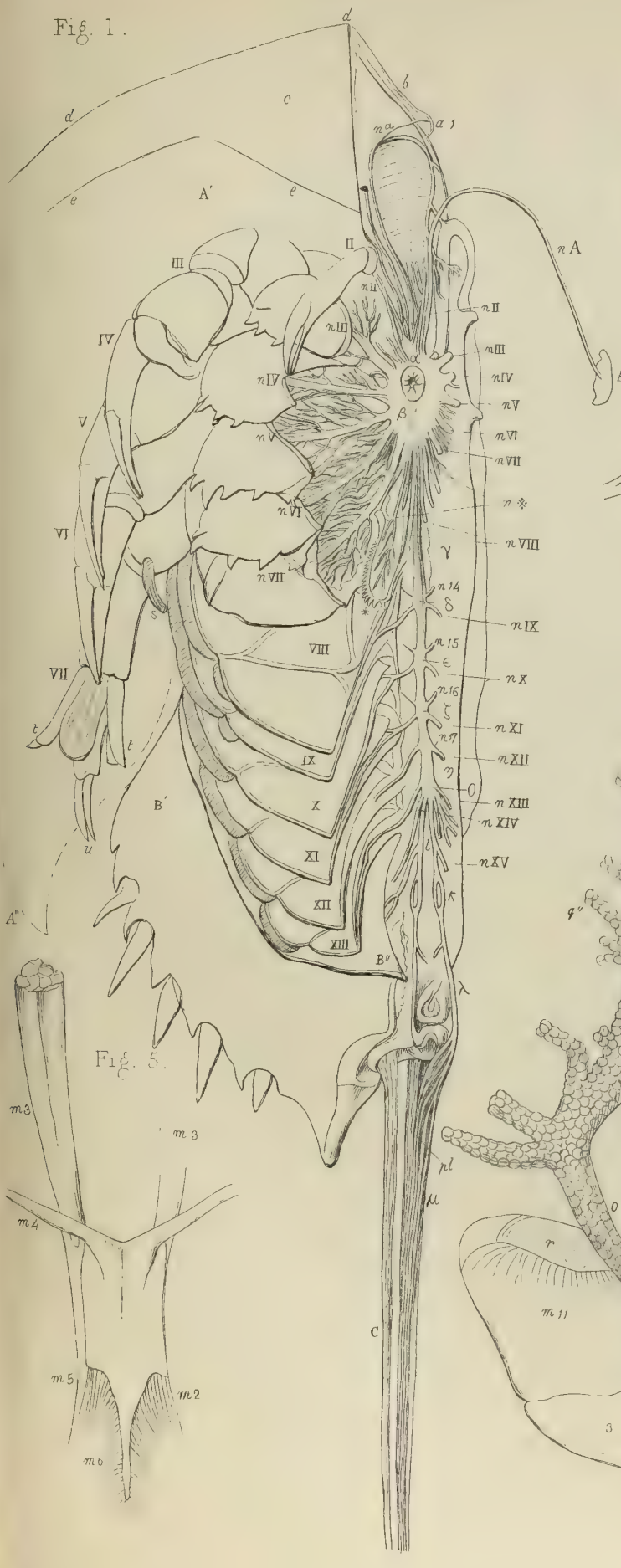


Fig. 3.

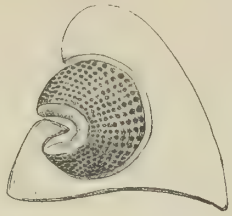


Fig. 2

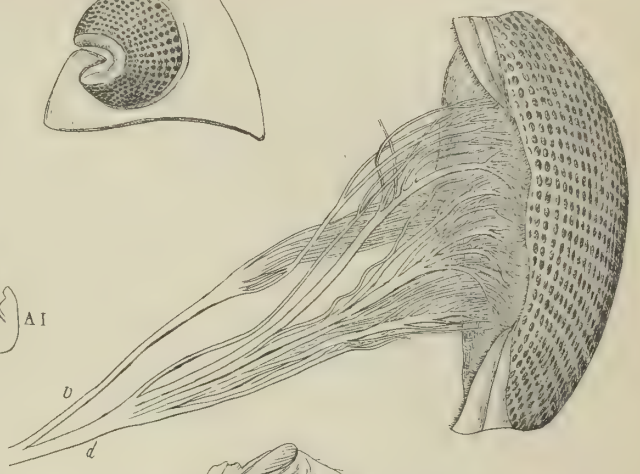


Fig. 8.

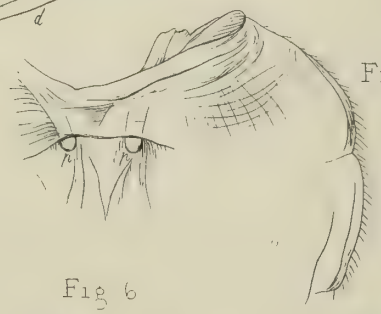


Fig. 4.

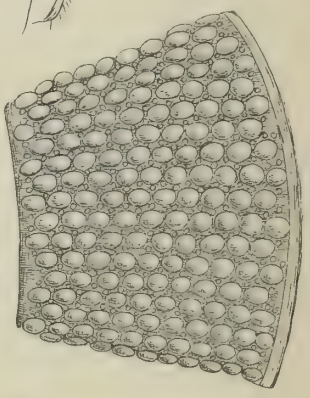


Fig 6

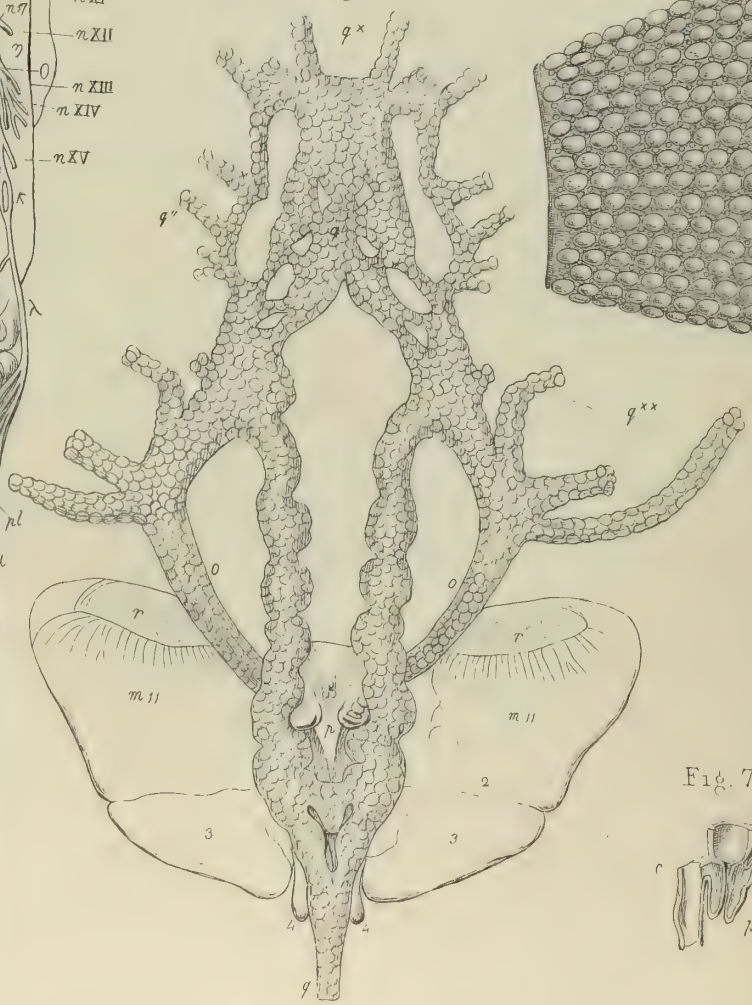
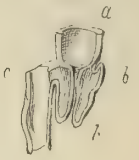


Fig. 5.

Fig. 7



ANATOMY OF LIMULUS POLYPHEMUS, LATR. *(after Owen)*

PLATE XXXVI.

Order—MEROSTOMATA.

Sub-Order—XIPHOSURA.

Anatomy of *Limulus polyphemus*, Latr. (after Owen).

FIG.

1. Nervous system seen from the upper or dorsal aspect. (Pp. 192—198.)
   a. Supra-œsophageal mass. B. Œsophageal ring. *n a*. Ocellar nerve. *n* A. Ocular nerve. *n* 3. Gastric nerve. *n* 4. First epimeral nerve. *n* 5. Second epimeral nerve. *n* 6. Its recurrent branch. *n* 7 to *n* 19. Third to fifteenth epimeral nerves. *pl*. Pleonal plexus.
2. Left branchigerous limb with attached branchiæ. (P. 207.)
3. Branchial lamellæ. *a*. Efferent plexus. All the figures, save where otherwise stated, are of the natural size.

[The permission to use the stones of our Plates XXXIV—XXXVI, which are a reproduction of those numbered Pls. 37, 38, and 39, illustrating Prof. Owen's Memoir (Trans. Linn. Soc., 1872, vol. xxviii, pp. 459—506), has been most kindly accorded by the Council of the Linnean Society with the approval of the author, Prof. Owen, C.B.]

Fig. 1.

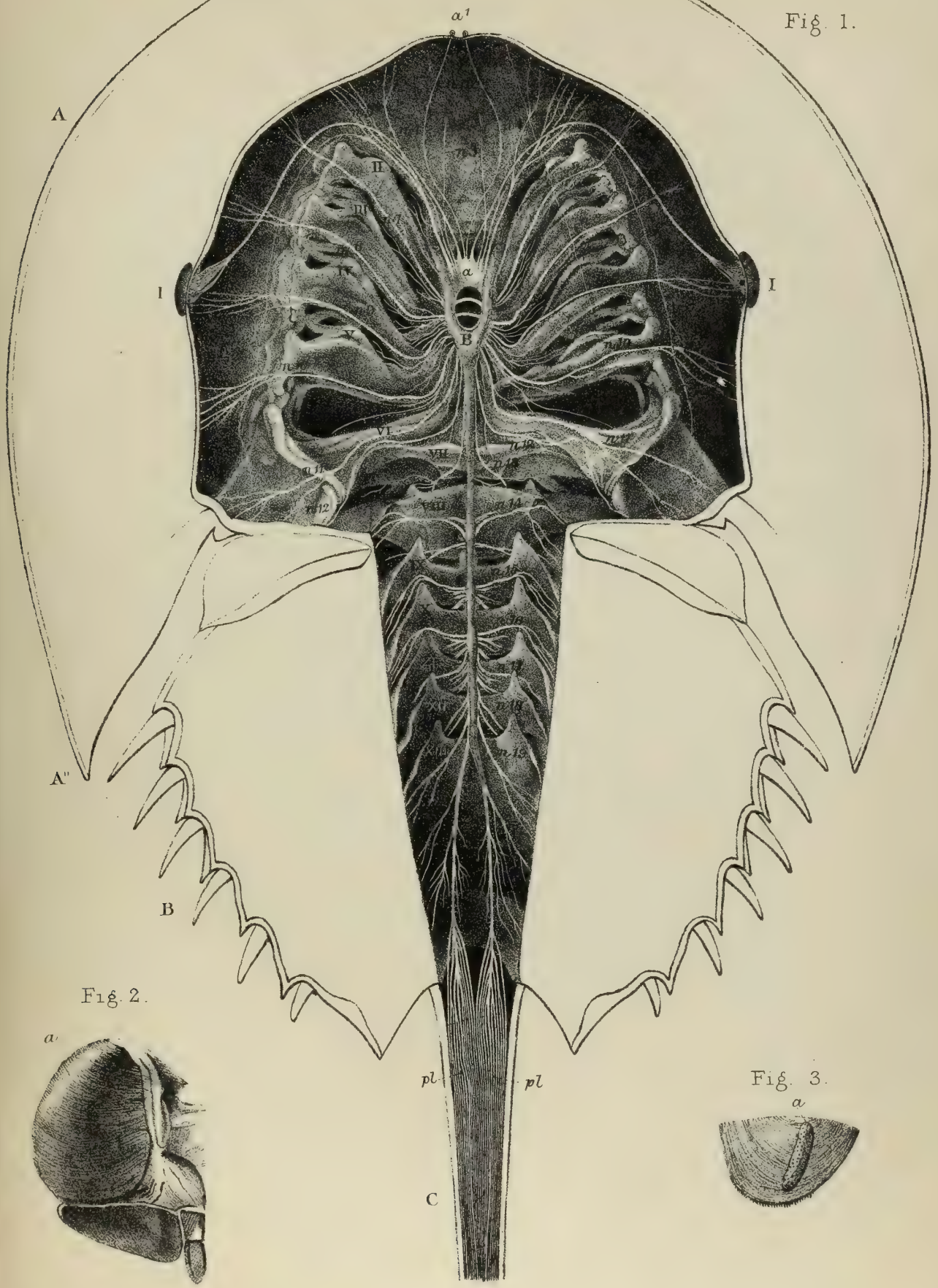


Fig. 2.

Fig. 3.

ANATOMY OF LIMULUS POLYPHEMUS, LATR. *(after Owen.)*

Leighton Bros

THE

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A MONOGRAPH

OF THE

BRITISH FOSSIL BRACHIOPODA.

BY

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VOL. IV.

PART II. No. 2.

SUPPLEMENT TO THE JURASSIC AND TRIASSIC SPECIES.

PAGES 145—241; PLATES XVII—XXIX.

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" Found in stone excavated for the alterations and improvements of the road between Nunney and Frome, by my kind friend the Rev. John Ireland, who first pointed it out as distinct." These quarries are in Green Pits Lane near Nunney and are now closed. Mr. Walker, however, found a worn specimen of the species there last year among the débris of the quarry.

This variety varies considerably in shape, for some specimens are regularly oval and uniformly convex, the mesial fold being almost obsolete, while in others there exists every gradual passage into the slightly pentagonal shape and defined fold. In the ventral valves there appears to exist a shallow median sinus. The external surface is covered with numerous, fine, radiating, slightly raised lines, which are closely intersected by concentric lines, giving a finely imbricated appearance to the surface, but not so spinulose as in true *T. coarctata*. This form occurs in the Inferior Oolite near Frome, and good examples may be seen in the Museum of the School of Mines, and in the collection of Mr. J. F. Walker. I believe one of Smith's original specimens is in the British Museum. Mr. J. F. Walker recently found a very fine specimen (Sup., Pl. XXV, fig. 3) in the Fuller's-earth Oolite in the road-side cutting near Whatley Church, associated with *T. globata*, *Wald. bullata*, and *Rhynchonella varians*, var. *Smithii*.[1] The variety is closely related to *Terebratula hybrida*, 'E. Desl., Pal. Franç.,' pl. lxvi,, figs. 1—6. It differs, however, from these figures in having the smaller valve more rounded and the fold less conspicuous. *T. hybrida* occurs in the Inferior Oolite of Calvados.

120. ? Terebratula infra-oolitica, *E. Desl.* Dav., Sup., Pl. XVIII, figs. 8, 9.

Terebratula infra-oolitica, *E. Desl.* Brach. Jur., Pal. Franç., p. 210, pls. lviii, lix, fig. 1, 1864.

Shell somewhat sub-pentagonal, longer than wide, broadly rounded anteriorly and slightly indented in front, tapering posteriorly; valves moderately convex. In the dorsal valve a moderately elevated and gently biplicated fold occupies the central portion of the anterior half of the shell, the two rounded plications are rather close together, with a narrow sinus between them. In the ventral valve a slightly raised fold commences about the middle of the valve and extends to the front, a narrow concave groove being

[1] It has doubtless been observed that various figures of specimens of the same species have been occasionally drawn on different plates, and sometimes out of their regular order. This arrangement has been necessitated by my desire of always giving figures of the best obtainable examples of any species, and as specimens have been coming in up to the moment of sending to press and during the drawing of the plates, I have been compelled to place them in the best available positions. During the three years this Supplement has been in preparation I have been most zealously assisted by several friends, whose names are recorded in the work, and to whom I would again tender my warmest acknowledgments.

observable on either side. Beak moderately incurved and truncated by an foramen, slightly separated from the hinge-line by short deltidial plates. Length, 1 inch 4 lines; width, 1 inch, 1 line ; depth, 8 lines.

Obs.—This is another of those perplexing ill-defined biplicated forms which can be scarcely distinguished with any degree of certainty. Mr. E. Deslongchamps, to whom I submitted the shells under description, at once identified them with his *T. infra-oolitica*, and added that they agreed with those he had found in France. The species varies considerably in shape, and seems remarkable from the disposition of its frontal plications, which are situated on a raised mesial fold, somewhat as is seen in *Ter. sella* from the Neocomian formation. It bears much resemblance to a small variety of *Ter. intermedia* (var. *Laigntonensis*) from the Cornbrash of Laignton Herring, near Weymouth. Mr. Deslongchamps states that it forms a connecting link between *T. intermedia*, *T. globata*, and *T. Eudesei*, and does not fail to add, " C'ést donc une de ces éspèces mal définies, comme nous en avons deja rencontré plusieurs fois, et qui prendront leur caractères definitifs dans les périodes suivantes." It approaches also much to *Ter. Stephani*, but in this last-named shell the biplication of the valves is much stronger and more on a level with the almost straight front line. I introduce the species here on the special authority of Professor E. Deslongchamps, who believes that on account of certain small specific differences and its geological position it should, provisionally at least, retain a separate designation. It is also not very unlike some specimens of *T. gregaria*, Suess, figured by Mr. E. Deslongchamps in pl. viii *bis* of his ' Brachiopodes Jurassiques.'

Geological position.—This shell was found by the Rev. F. Smithe in the *Ammonites jurensis* zone, the base of the Inferior Oolite or passage-beds between the Upper Lias and Inferior Oolite. Mr. E. Deslongchamps and other French geologists place those beds in their " étage infra-oolitique." It is the Falciferen-Zone of Dr. Brauns. Messrs. Tate and Blake in the " Yorkshire Lias " (p. 16) consider the upper portion of Dr. Wright's Upper Lias Sands to belong to the Inferior Oolite, and the lower portion to the Upper Lias. It is, therefore, evident that there is no sharp line of separation between the highest beds of the Upper Lias and the lowest one of the Inferior Oolite.

I am informed by the Rev. F. Smithe that the *Am. jurensis* sands are about 150 feet in thickness at Frocester Hill. The specimens of *T. infra-oolitica* were discovered by him at about the middle of that formation. *Terebratula punctata* and the var. *Haresfieldensis*[1] occurred in the lower Cephalopod-bed lying immediately above the upper portion of the *Am. jurensis* zone, and *Rh. cynocephala* was found in a small ferruginous band over it.

Mr. E. Deslongchamps states that *T. infra-oolitica* prevails on the Continent in the lower portion of the Infra-oolite Marls (level of *Am. opalinus*) in the neighbourhood of Potiers, of Niort, Saint-Maixent, Montreuil-Bellay, &c. (Dep. des Deux Sevres), and in several others.

[1] In the first part of this Supplement the name Haresfield has been inadvertently spelt with a *v*.

121. Terebratula Stephani, *Dav.* Sup., Pl. XVIII, figs. 1—7.

Terebratula sub-maxillata, *E. Desl.* (not of *Davidson*). Brachiopodes Jurassiques, p. 270, pls. lxxvii and lxxviii, 1872.

— Stephani, *Dav.* Proc. of Dorset Nat. Hist. and Antiquarian Field Club, vol. i, pl. i, fig. 3, 1877.

Shell sub-pentagonal, longer than wide, strongly biplicated, widest about the middle. Dorsal valve moderately convex, with two more or less prominent folds on the posterior half of the valve. These rounded folds are more or less widely apart, leaving between them a sinus of greater or lesser depth. Ventral valve rather deeper or more convex than the dorsal one, with a more or less prominent rounded longitudinal fold, especially developed in the posterior half of the valve. On either side is a deepish concave furrow, corresponding with the folds in the dorsal valve; beak incurved, foramen but slightly separated from the hinge-line by a small deltidium. Loop short, surface smooth. Two specimens measured—

Length 1 inch 9 lines; width 1 inch 3 lines; depth 12 lines.
„ 1 „ 6 „ „ 1 „ 4 „ „ 10 „

Obs. This is the shell described and figured by Mr. E. Deslongchamps at p. 270 of his 'Brach. Jurassiques' as my *T. sub-maxillata*, but I was able to convince my distinguished friend during his visit to Brighton in 1876 that he was mistaken in his identification. *T. Stephani* appears to be very abundant in the Inferior Oolite of several localities, especially at Bradford Abbas, Broadwinsor, and several other places in Dorset and Somersetshire, where Mr. Darell Stephens, to whom I dedicated the species, picked up and forwarded for my examination more than two hundred specimens. None of the examples much exceeded the dimensions above given. It varies very considerably in shape and seems to be intermediate between *Ter. perovalis* and *T. Phillipsii*, but is, even when adult, a much smaller shell. Its strongly biplicated valves distinguish it from *T. perovalis*, and it is comparatively less broad than *T. sub-maxillata*.

The Bradford Abbas specimens agree exactly in shape with those figured by Mr. E. Deslongchamps from the Inferior Oolite of the Department du Calvados in France, where the fossil is stated to be very abundant. The same French palæontologist quotes it from Stuifemberg, Bopfingen, Brauweberg, Balingen (Wurtemburg), Liestal, Aaran, Switzerland, and also from Spain.

122. Terebratula subsella, *Leymerie*. Dav., Sup., Pl. XIX, figs. 10, 11, 12.

Terebratula subsella,	*Leymerie.*	Stratigraphie géol. de l'Aube, p. 249; Atlas, p. 10, fig. 5, 1846.
—	— *de Loriol.*	In P. de L. E. Royer et H. Tombeck's Monogr. des Étages Jurassiques Sup. de la Haute-Marne, p. 412, pl. xxv, figs. 2—20, 1872.
—	— *Cotteau.*	Monog. de l'Étage Portlandien de l'Yonne, p. 216, pl. xiii, figs. 11, 12, 1868.
—	— *Rigaux.*	Notice Stratigraphique sur le Bas Boulonnais, p. 20, 1365.
—	— *Ogérien.*	Hist. Nat. du Jura, vol. i; Géol., p. 620, 1867.
—	suprajurensis, *Jaccard.*	Desc. géol. der Jura Vaudois et Neuchâtelois, pp. 193 et 199, 1868.
—	— *Greppin.*	Desc. géol. des Jura Bernois (Matériaux pour la Carte Géol. de la Suisse, 8 liv.), 1870.
—	— *Lennier.*	Études Géol. et Pal. sur les Falaises de la Haute Normandie, p. 110, 1872.
—	subsella, *Struchmann.*	Die Pterocerasschichten bei Ahlem; Zeitschrift des Deutschen Geol. Gesell., pp. 221—227, 1871.
—	— *D. Brauns.*	Obere Jura in Nordw. Deutschland, p. 371, 1874.
—	— *Douville.*	Fossiles du Jurassique Moyen du Berry, Bull. Soc. Géol. de France, 3me sér., tom. iii, p. 124, 1875.
—	— *de Loriol.*	Mon. des Étages Sup. de la Formation Jurassique de Boulogne-sur-Mer, Suppl., p. 236, pl. xxv, figs. 17, 18, 1875.
—	— *J. F. Walker.*	Geol. Mag., p. 574, 1876.

Shell sub-pentagonal, rather longer than wide, broadest about the middle, valves nearly equally deep. Dorsal valve biplicated at its anterior half, the rounded folds being rather close and separated by a depression of moderate depth. In the anterior half of the ventral valve a longitudinal fold corresponds with the median depression in the opposite valve. Beak much incurved and truncated by a circular foramen lying close to the hinge-line or umbone of the smaller valve. Front line **M**-shaped, the two central lines being very much shorter than the outer one. Surface smooth. Loop in the dorsal valve short. Two specimens measured—

Length 17, width 14, depth 9 lines.
„ 14, „ 12, „ 8.

Obs.—The discovery of this important fossil as a British species is due to Mr. J. F. Walker, who found it in 1876 in the Supra-Coralline Bed or red ferruginous rock at

Abbotsbury, near Lyme Regis in Dorsetshire, associated with *Wald. lampas*, *W. Dorsetiensis*, and *Rh. pinguis*, var. *pectunculoides*. The shells are of an ochreous-brown colour, due to the matrix, and occur chiefly in the condition of internal casts. *T. subsella* sometimes so much resembles *Ter. sella* from the Neocomian formation, that in 1846 it was mistaken for that species by Mr. Leymerie, who described and named the shell under description.

It varies chiefly in the degree of approximation and projection of its two rounded folds and in the depth of the sinus which separates them. The shell has been most carefully described and illustrated by Mr. de Loriol from specimens derived from the Kimmeridge Clay of the Boulonnais, where I found it for the first time upwards of thirty years ago. It was subsequently met with by Mr. Pellat at different levels in the same formation, the most typical examples occurring in the zone characterised by an immense abundance of *Ostrea virgula*. It occurs likewise lower down in the upper beds of the "Étage Séquanien," from which horizon our British specimens are apparently derived. Mr. de Loriol mentions its occurrence in a number of other places, such as at Cirey, Rachecourt, Bure, Nully, in the zone of *Cyprina Brongniarti* (Étage Portlandien); Pancey-Rupt, Blaise, zone of *Am. caletanus* (Étage Virgulien); Harméville, Blaize, zone of *Am. orthocera*, Ptérocérian zone; Champcourt, Harméville; 2nd zone of *T. humeralis*; Soncourt, 1st zone of *T. humeralis*, Étage Séquanien. Oppel (Die Jura) states that it occurs in the zone of *Pterocera oceana*, at Lindener and Tönnies Berg, near Hanover, also in the Grey Marl of Arensburg, near Bückeling, east of Minden, and in the Kimmeridge Clay of Havre and Honfleur, and that it abounds in the zone of *Pterocera oceana* of Tonnère, Yonne.

Terebratula globata, *Sow.* Sup., Pl. XVII, fig. 3 (see p. 135).

Specimens of this typical form of *T. globata* have been found at Whatley Church, near Frome, and at Burton Station in the Fuller's Earth Rock, by Mr. J. F. Walker, along with *Wald. bullata*. It is probable that Sowerby's type from Nunney, near Frome, came from this rock. Another variety of *Ter. globata* occurs in the Inferior Oolite of Leckhampton Hill, Gloucestershire. It differs from the type-specimens in being more tumid, the valves being convex, and the plications not extending so far up the valves; the outline of the shell is rounder. The beak is short, incurved, the foramen large, and the hinge-line straighter. It might be called *T. globata*, var. *tumida*.

123. Terebratula globata, var. Birdlipensis, *Walker MS.* Sup., Pl. XVII, figs. 18, 19, 20, 21.

This fossil (according to Mr. J. F. Walker) is the variety pointed out by Dr. Lycett at p. 134 of his "Cotteswold Hills" as differing from Sowerby's species.[1] I quite concur in the view he has taken in the matter. The shell is elongated, oval, with very convex, almost gibbous valves, and when full grown is massive. The dorsal valve is very much swollen out, especially at and near the umbone, uniformly convex to within one half and sometimes two thirds of its length. When the valves become gradually biplicated the two folds are rounded, close to each other, and separated by a deepish sinus of about the breadth of one of the folds. The ventral valve is very deep and uniformly convex to about one third of its length from the beak, when a rounded, longitudinal, mesial fold gradually rises and extends to the front; on either side a narrow, concave depression corresponds to the fold on the dorsal valve. The beak is large and broadly rounded, incurved, and truncated by a circular foramen lying close to the umbone of the dorsal valve; frontal line strongly bisinuate, and often very much thickened. Surface smooth; loop short. Proportions variable; an average-sized specimen measured—

Length 1 inch 5 lines; width 1 inch; depth about the same.

Obs.—This well-marked variety occurs abundantly in the Clypeus-grit of the Inferior Oolite at Birdlip Hill, near Cheltenham. It differs from Sowerby's *T. globata* in being more elongated, and the anterior folds are more strongly defined. It is also more globose. Specimens of this variety were found by Mr. J. F. Walker in a blue rock at the base of the Fuller's-earth Oolite at Sapperton Tunnel, Gloucestershire.

124. Terebratula Bradfordiensis, *Walker MS.* Dav., Sup., Pl. XVII, fig. 6.

Shell sub-pentagonal, longer than wide, biplicated close to the frontal margin, tapering towards the beak, plications rounded, frontal line bisinuated; valves very moderately convex, somewhat flattened; beak incurved, and truncated by a circular foramen lying close to the hinge-line; loop short; surface smooth.

Length 9, width 8, depth 4 lines.

Obs.—Since I alluded to this shell at p. 140 of this Supplement Mr. J. F. Walker has given it the name of *Bradfordiensis*. He considers it to be specifically separable from *Ter. Ferryi*, as it is always small, remarkably flat, and the plications are not so extended.

[1] The larger specimen alluded to at p. 136, Pl. XVII, fig. 1, of this Supplement is a large form of a variety of *T. globata*, differing from the Sowerby type in some particulars.

It is a common shell in the Bradford Clay at Tetbury Road Station, and Bradford, Wilts, and Radipole, near Weymouth. It seems to belong more to the *T. perovalis* than to the *T. globata* group. It occurs with *Wald. digona*.

125. Terebratula decipiens, *E. Desl.* Ool. Mon., Pl. XI, figs. 16, 17, 18; and Sup., Pl. XX, figs. 4, 5, 6, 7, 8.

Terebratula sphæroidalis, *d'Orb.* (pars). Prodrome, No. 449, 1849. Non *T. sphæroidalis*, Sow.
— — *Dav.* (not *Sow.*). Ool. Mon., p. 56, pl. xi, figs. 16—18.
— decipiens, *E. Desl.* Brach. Jurassiques, p. 285, pl. lxxxiii, 1873.
— — *Dav.* Proc. of the Dorset Nat. Hist. and Antiq. Field Club, vol. i, pl. ii, fig. 1, and pl. iii, fig. 3, 1877.

Shell oval, longer than wide; valves uniformly convex and deep, without fold or sinus; front line straight or slightly curved; beak closely incurved over the smaller valve, and truncated by a somewhat oval foramen. Surface smooth; loop short. Two specimens measured—

Length 2 inches 4 lines; width 1 inch 9 lines; depth 1 inch 7 lines.
„ 1 „ 4 „ „ 1 „ 2 „ „ 11.

Obs.—This species is nearly allied to *T. sphæroidalis*, but is distinguishable, according to Mr. E. Deslongchamps, by its greater length compared with its width, larger foramen, and lesser convexity. The specimens I have figured in this Supplement were at once recognised by Mr. E. Deslongchamps as belonging to his species, to which we must also refer those represented in Pl. XI, figs. 16—18, of my Oolite Monograph. It varies considerably in size, and occurs rather abundantly in the Inferior Oolite of Bradford Abbas, Half-way House, and other places in Dorset and Somersetshire; also at Dinnington. Mr. E. Deslongchamps states that it is found in great abundance in all the Provence, and part of Languedoc, at Bandol, Cuers, &c., in France. It has also been met with in Spain.

126. Terebratula Craneæ, *Dav.* Sup., Pl. XX, figs. 1, 2.

Terebratula Craneæ, *Dav.* Proc. of the Dorset Nat. Hist. and Antiquarian Field Club, vol. i, pl. ii, fig. 3, 1877.

Shell elongated, oval, broad anteriorly, tapering posteriorly, nearly straight in front, sides gently convex; dorsal valve moderately deep, with a very wide fold scarcely rising above the regular convexity of the valve, tolerably defined by two fine lines. Ventral

valve twice as deep as the opposite one, broadly flattened longitudinally from the extremity of the beak to the front, the lateral portions of the valve being likewise flattened and sloping rapidly from the edge of the mesial space; beak very short, and truncated by a rather small, circular foramen; lateral margin presenting a convex curve; loop not known. Surface smooth, marked by concentric lines of growth. Two specimens measured—

Length 2 inches 3 lines; width 1 inch 5 lines; depth 1 inch 3 lines.
„ 2 „ 1 „ „ 1 „ 4 „ „ 1 „ 2 „

Obs.—This remarkable species is at once distinguishable from all its British congeners by its peculiar shape and character. Mr. Walton, of Bath, gave me a specimen of it some years ago, which had been obtained from the Inferior Oolite, near Sherborne, and another rather larger, but in other respects exactly similar, example, was lent to me by Mr. Darell Stephens from the same locality.[1] I have named it after Miss Agnes Crane, a talented young palæontologist to whom science is indebted for several excellent papers.

127. Terebratula Whitakeri, *Walker MS.* Sup., Pl. XIX, figs. 6, 7, 8, 9.

Shell as broad as long, or a little longer than wide, circular, or slightly longitudinally oval. Dorsal valve moderately convex, fold broad and scarcely raised above the general convexity of the valve, and sloping almost insensibly into the general convexity of the valve. Ventral valve rather deeper and more convex than the opposite one, with a broad, shallow sinus. Front line formed into a rounded wave, sides rounded; margins of valves very sharp; beak short, incurved, and truncated by a circular foramen situated in close contiguity to the umbone of the opposite valve; loop not known, in all probability short. Surface smooth. Two specimens measured—

Length 1 inch 5 lines; width 1 inch 3 lines; depth 10 lines.
„ 1 „ 4 „ „ 1 „ 4 „ „ 9 „

Obs.—This species seems, as far as I have been able to judge from the inspection of eight specimens placed in my hands by Mr. J. F. Walker, to be persistent in shape and

[1] By some mistake the locality of Yeovil has been several times given to Inferior Oolite fossils, but there is no Inferior Oolite at Yeovil itself, although it occurs near by. Professor Buckman writes to me upon this subject: "Bradford Abbas is in Dorsetshire, but nearer Yeovil than it is to Sherborne, hence, perhaps, some mistake may have arisen about localities. My quarry and the celebrated Half-Way House quarry have yielded most of the fossils from the Inferior Oolite of Dorsetshire. Sherborne is mostly on Fuller's Earth, and the hills around me are Inferior Oolite, hence the Fuller's Earth is faulted down. My village, Bradford Abbas, is on Fuller's Earth faulted in like manner. Yeovil is on Upper Lias, and the Yeo thence to Bridgewater runs along the Lower Lias shale. The Inferior Oolite has yielded numerous species of Brachiopods at the following localities: Bradford Abbas, Half-Way House, Bridport Station, near Sherborne, Scavington, Milborne Wick, Haselburg, Crewkerne Station, and Broadwinsor."

character. It is remarkable on account of its peculiar broad fold, the sharp edges of its valves, and short beak. The absence of biplication distinguishes it from *T. infra-oolitica*, although Mr. E. Deslongchamps figures under that designation (Pl. 58, fig. 5 of his 'Brachiopodes Jurassiques') a specimen which bears some resemblance to the shell under description. The absence of biplication distinguishes it likewise from *T. submaxillata*. One example among Mr. J. F. Walker's specimens shows a tendency to the formation of short, irregular plications round the margin of the valves, but this was no doubt due to malformation. *Ter. Whitakeri* occurs in the Oolitic Marl (Inferior Oolite) of Leckhampton Hill, near Cheltenham. Mr. Walker has named this species after his friend, Mr. W. Whitaker, F.G.S., editor of the 'Geological Record.'

128. Terebratula curvifrons, *Oppel.* Dav., Ool. Mon., Pl. IV, figs. 15, 16; Appendix to Vol. I, Pl. A, fig. 17; Sup., Pl. XXIV, fig. 33.

Terebratula resupinata, *Quenstedt* (pars). Handbuch der Petrefactenkunde (Br. Jura), p. 469, tab. xxxvii, fig. 38, 1851 (not *T. resupinata*, Sow.).

— carinata, *Dav.* (pars). Ool. Mon., p. 35, pl. A, fig. 17, 1855.

— — *De Ferry.* Note sur l'Étage Bajocien des Environs de Macon., p. 13; Mém. Soc. Linn. de Normandie, vol. xii, 1861.

— curvifrons, *Oppel.* Die Jura-Formation, p. 423, 1857.

— Brebissoni, *E. Desl.* Bull. Soc. Linn. de Normandie, vol. vii, p. 321, 1862, and Études Critiques sur les Brachiopodes Nouveaux ou peu Connus, 3rd fascicule; Bull. Soc. Linn. de Normandie, vol. viii, p. 251, pl. ix, figs. 1—8.

— (epithyris) curvifrons, *E. Desl.* Brach. Jur., p. 187, pl. xlix, figs. 1—8, 1864.

Shell broadly subpentagonal, as wide as long or a little longer than wide, slightly indented in front. Dorsal valve moderately convex, especially at the umbone and lateral portions of the valve; divided into two parts by a groove or depression of moderate depth, commencing at a little distance from the umbo, and widening as it approaches and reaches the front. Ventral valve deep and keeled; beak moderately produced, and truncated by a rather large foramen, margined anteriorly by a small deltidium in two pieces; beak ridges well defined. Surface smooth, marked at intervals by concentric lines of growth.

Length nearly 2 inches; width 1 inch 9 lines; depth 11 lines.

Obs.—The loop is not known, but Mr. Deslongchamps surmised from external appearances, and the absence of a dark longitudinal line along the middle of the umbone,

that this species was possessed of a short loop as in the sub-genus *Epithyris* of King. An internal cast of the smaller valve from Cheltenham, in the possession of Mr. J. F. Walker, shows that the shell was not possessed of a septum, and consequently would belong to those species of *Terebratula* that are provided with a short loop. This is the more remarkable, as the shell bears much external resemblance to *Wald. carinata*. It is, however, a much broader shell.

T. curvifrons occurs in the lower beds of the Inferior Oolite in England, and is not a rare shell in that formation at Crickley Hill, Cheltenham (Buckman). It is also found in the Inferior Oolite of Leckhampton Hill, Hartley Bottom, and Charlton Common, near Cheltenham. In France it is, according to Mr. E. Deslongchamps, restricted to the lowest beds of the Inferior Oolite (or Infra-Oolitic marls characterised by *Am. Murchisoni*, *A. Sowerbyi*, and *A. primordialis*), and can be collected at May and Fresnay-la-Mère in Normandy. It has been met with by M. Jaubert in the departement of the Var, in the zone characterised by *Am. Murchisoni*, *Lima heteromorpha*, *Pecten barbatus*, &c. Dr. Oppel appears to have found the species in Germany, at the base of the zone of *Am. Parkinsoni* at Nipf, near Bopfingen.

129. Terebratula Boloniensis *Sauvage* and *Rigaux*. Dav., Sup., Pl. XIX, figs. 1, 2.

Terebratula Boloniensis, *Sauvage* et *Rigaux*. Journal de Conch., vol. xix, 3rd series, pl. cccliv, 1871, and vol. xx, p. 87, pl. ix, fig. 3, 1872.

Waldheimia — *De Loriol*. Mon. des Étages Sup. de la Formation Jurassique de Boulogne-sur-Mer, p. 237, pl. xxv, fig. 19, 1875.

Shell elongated, oval or sub-orbicular, longer than wide, dorsal valve slightly and evenly convex, sometimes much flattened; no fold. Ventral valve much deeper and more convex than the opposite one; beak moderately produced, incurved, and truncated by a small deltidium: beak-ridges sharply defined, leaving a flattened space between them and the hinge-line. Surface smooth and irregularly marked at intervals with concentric lines of growth and faint radiating lines. Length $1\frac{1}{2}$ inch; breadth 1 inch 5 lines; depth 8 lines.

Obs.—This species is remarkable on account of the flatness of its dorsal valve as compared with the ventral one. Messrs Rigaux and Sauvage first discovered the species in the middle Portlandian of Boulogne-sur-mer. It has been well described and figured by them, and by Mr. de Loriol. In 1877, Mr. E. Rigaux, while visiting Oxford, was conducted by Mr. James Parker to the Coral-rag pits at Bullingdon Green (N. E. pit) close to Shotover Hill, and there picked up the fragment we represent (Sup., Pl. XIX,

fig. 1). This shell appears to be exceedingly rare, as no other example of the species is recorded from the locality. On his return to Boulogne Mr. E. Rigaux kindly sent me the fragmentary specimen above mentioned, with others of *T. Boloniensis* from Boulogne-sur-Mer, observing at the same time that he believed the Bullingdon fossil to be referable to the same species. Another perfect British example of this species, from the Coral-rag of Malton in Yorkshire (Sup., Pl. XIX, fig. 2), was found by Mr. Walker in the Leckenby collection in the Woodwardian Museum, Cambridge. *Ter. Boloniensis* is also an uncommon fossil in the Middle Portlandian beds of the Boulonnais. It has been found at the Tower Croi, Alprech. Mr. E. Rigaux informs me that he only obtained seven specimens in eighteen years, and M. de Loriol also knows of but very few examples. We are not acquainted with any British species of *Terebratula* in the Portland series; and indeed no Brachiopod is known to me from that formation, except an uncertain fragment of a *Rhynchonella* which Mr. James Parker believed was obtained from the Portland of the upper portion of Shotover Hill, Oxford. Mr. Parker also mentions that he found a *Terebratula* (Sup., Pl. XIX, fig. 3), bearing much resemblance to *T. Boloniensis*, in the Oxford Clay of St. Clements, Oxford.

130. Terebratula Gesneri, *Étalon.* Dav., Sup. Pl. XIX, figs. 4, 5.

Terebratula Gesneri, *Étalon.* Lethæa Bruntrutana, p. 287, pl. xli, fig. 10, 1861.

Shell elongated oval, longer than wide, rounded in front. Ventral valve convex and deeper than the opposite one; beak moderately produced, incurved, and truncated by a circular foramen, slightly separated from the hinge-line by a deltidium in two pieces; beak-ridges sharply defined, with a flattened space between them and the hinge-line. Dorsal valve evenly convex without fold. Surface smooth, marked at intervals with concentric lines of growth. Length 13, width $10\frac{1}{2}$, depth $7\frac{1}{2}$ lines.

Obs.—With some uncertainty this species is referred to *T. Gesneri* of Etalon. Mr. James Parker obtained three examples of different ages from the Coral-rag of Bullingdon and Horsepath pits, close to Shotover Hill, Oxford, and there is a fragment of the same species from the last-named locality in the Oxford Museum. The shell is smaller than *T. Boloniensis*, and is more elongated and oval. The dorsal valve is also more convex. It resembles, as far as I can judge from the figures of Étalon's *T. Gesneri*, which, according to that geologist, occurs in the Astartian zone of his Portlandian at Bure and Blauen in the Bernese Jura, where it is said also to be rare. This species seems to be nearly allied to *T. insignis*.

131. Terebratula Buckmani, var. Buckmaniana, *Walker*. Sup., Pl. XIX, figs. 14—17.

This variety occurs at Cleeve Hill and in the Gryphæa-grit of Leckhampton Hill. It differs from the type (Pl. XIX, fig. 13) in being less regularly ovoid, widening towards the front margin. The smaller or dorsal valve is flatter and slightly compressed towards the sides of the lower third of the shell. In some examples it is also more or less biplicated towards the front. The ventral valve is widest about the centre of the shell with, in some specimens, a rounded median fold with two lateral depressions. Beak incurved and truncated by a circular foramen overlying the umbone of the opposite valve. Front margin straight or slightly bisinuated.

132. Terebratula Phillipsii, var. Phillipsiana, *Walker*. Dav., Sup., Pl. XVII, fig. 23.

A broad flat variety, which occurs in the Inferior Oolite of Cleeve Hill, Gloucestershire.

133. Terebratula intermedia, var. Langtonensis, *Walker*, MS. Dav., Sup., Pl. XVIII, fig. 14.

This variety does not appear to have attained more than half the size of *T. intermedia*. It is very abundant in the Cornbrash of Langton Herring, near Weymouth, where it is associated with *Rh. Boueti*. It has also been found by Mr. Darell Stephens in the Bradford Clay of Burton Bradstock with *Ter. coarctata*, *Wald. digona*, and *Rh. Boueti*. It is only a small race or variety of *T. intermedia*.

A small well-marked variety of *Terebratula perovalis* occurs also in the Gryphæa-grit of Leckhampton Hill (Sup., Pl. XVIII, figs. 10—13). This agrees in all respects, except in size, with the large *T. perovalis*, var. *ampla* of Buckman (Sup., Pl. XXV, figs. 1, 2), which is so abundant in the Inferior Oolite of Bradford Abbas in Dorset. Some specimens of these last measured 3 inches 2 lines in length, by 2 inches 9 lines in breadth and 1 inch 9 lines in depth.

134. Terebratula (?) Walfordi, *Dav.* Sup., Pl. XIX, figs. 18, 19.

Shell marginally longitudinally oval, broadest posteriorly. Dorsal valve very slightly convex, almost flat and even, sometimes slightly depressed longitudinally. Ventral valve

convex, most so posteriorly ; no fold nor sinus, margin-line straight ; beak small, incurved, and truncated by a comparatively large foramen touching the umbo of the opposite valve ; deltidial plates, small but broad and not united in front : hinge-ridges sharply marked, leaving between them and the hinge-line a flattened space. Surface smooth ; length 10, width 9, depth 5 lines.

Obs.—This species is remarkable on account of the flatness of its smaller valve, the whole shell reminding one of *Ter. hemisphærica,* but from which it is at once distinguished by its larger size and by the absence of the radiating lines observable in the last-named species.

It has been found by Mr. Walford in the Marlstone or Middle Lias of Aston-le-Walls near Banbury in Northamptonshire ; and it occurs also in the same formation at Adderbury, near Banbury in Oxfordshire. Mr. Innes Griffin has also found the shell in the *Am. spinatus* zone (Middle Lias) at King's Sutton, near Banbury. I have named it after Mr. Edwin A. Walford, to whom I am indebted for specimens and information with respect to the formations and species that occur in the neighbourhood of Banbury.

SPECIES WITH LONG LOOPS.

Genus Waldheimia, *King.*

135. Waldheimia quadrifida, *Lamarck,* sp. Dav., Ool. Mon., p. 28, Pl. III, figs. 8—10 ; Sup., Pl. XXI, fig. 20.

It is singular that almost every palæontologist in referring to this speeies has adopted Lamarck's name published in 1819. Therefore there are no synonyms to add to it, unless Sowerby's *T. cornuta* be considered no more than a variety of Lamarck's species. I feel persuaded the more I examine specimens of the two forms, that they merge so gradually one into the other that they are in reality only variations in shape of a single species. This view is shared by Mr. E. Deslongchamps, but, at the same time, he prefers to retain both names for the following reasons :—" La *T. quadrifida* passe par des dégrès insensible a l'éspèce suivante : plusieurs auteurs n'en font qu'une variété de la *T. cornuta* néanmoins comme la plupart des échantillons ont une forme assez accuseé, nous n'hésitons pas á la regarder comme èspèce, avec les restrictions que nous avons signaliés, p. 63. Cést-à-dire, que pour nous, le mot éspèce signifie simplement groupe de formes se convenant par un certain nombre de points communs et non point l'éspèce dans toute la

rigeur du mot." *W. quadrifida* occurs, associated with *W. cornuta*, in the upper portion of the Middle Lias or zones of *Am. capricornus*, *A. margaritatus*, and *A. spinatus*. It has been found by the Rev. F. Smithe in the zone of *Am. margaritatus* (Middle Lias) at Church Hill in Gloucestershire.

136. Var. CORNUTA, *Sow.*, 1824. Dav., Ool. Mon., p. 29, Pl. III, figs. 11—18; Sup., Pl. XXI, fig. 19.

I have not much to add to my statements with respect to this fossil at p. 29 of my Monograph. Mr. Deslongchamps was mistaken when placing *W. lampas*, Sow., as a synonym of *cornuta*: an error he now candidly admits, having had an opportunity of examining specimens of *W. lampas*. *W. cornuta* sometimes attains to large dimensions in the Middle Lias at Chidecock near Charmouth. In some specimens of *W. cornuta* the front is nearly straight without any marked indentation.

137. WALDHEIMIA MARIÆ, *A. d'Orb.*, sp. Sup., Pl. XXI, figs. 16, 17, 18.

TEREBRATULA MARIÆ, *A. d'Orbigny*. Prodrome, No. 236; Étage Liasien, 1849.
WALDHEIMIA — *E. Desl.* Brac. Jurassiques, p. 100, pl. xx, figs. 1—7, 1863.
— — *R. Tate*. Geol. Mag., vol. vi, p. 551, note, 1869.

Alcide d'Orbigny did not describe or illustrate his species, but Mr. E. Deslongchamps has done so at p. 100 of his 'Brachiopodes Jurrassiques, and as some specimens obtained by Mr. J. F. Walker from the Middle Lias of Charmouth near Lyme Regis, as well as of South Petherton near Ilminster, and another found by the Rev. F. Smithe in the zone of *Am. margaritatus* (Middle Lias) at Churchdown, Gloucestershire, entirely agree with the description and figures of the French species, we feel satisfied as to their identity. This identity was moreover confirmed by Mr. E. Deslongchamps during his visit to Brighton in 1876.

W. Mariæ is suboval or subglobose. Longer than wide, or about as long as wide, smooth, much swollen out about the middle portion of the shell, truncated or very slightly bilobed in front. Valves almost equally convex, and often much thickened at the margin; beak incurved and truncated by a small circular foramen completed by a deltidium in two pieces; beak-ridges very sharply defined; no fold or sinus in either valve. Proportions variable; an average-sized specimen measured—

Length 11, width 9, depth 9 lines.

Obs.—*Waldheimia Mariæ*, according to Mr. E. Deslongchamps, varies much in shape. Some examples are elongated and moderately convex, while others are about as long as wide and almost spherical. Mr. E. Deslongchamps considers this shell to be a

variety of *W. cornuta*, and that passages in shape connecting it with *W. cornuta* and *W. quadrifida* are readily found; but the difference between *W. Mariæ*, *W. cornuta*, and *W. quadrifida* appears to me greater than that which exists between the two last-named forms. Some of the smaller specimens somewhat resemble *W. anglica*, Oppel, of the Inferior Oolite, but differ from that species in the beak-ridges being more sharply defined and the beak more incurved, and in the greater convexity of the valves.

W. Mariæ is very abundant in the Middle Lias of Normandy, Yonne, in central France, and at Aragon in Spain.

138. Waldheimia indentata, *Sow.*, sp., 1824. Dav., Ool. Mon., p. 46, Pl. V, figs. 25, 26; Sup., Pl. XXI, figs. 10—15.

Since the publication of my description and figures of this species in 1851 I have had, through the kindness of Mr. J. de C. Sowerby, the loan of Sowerby's original examples, which are now in the British Museum. Of these, four agree with the figured type, being indented in front, while the remaining three showed no indentation. Mr. Beesley and Mr. E. A. Walford have found well-marked specimens with and without indentation in the *Am. spinatus* Zone at Thenford, Northamptonshire, about six miles to the east of Banbury), associated with *Ter. Edwardsii*, *Rh. tetrahedra*, and *Spiriferina oxygona*. Mr. E. A. Walford has also found the shell occurring in abundance, in the Marlstone Rock, along with *T. Edwardsii*, at Appletree and Aston-le-Walls in Northamptonshire, about eight miles from Banbury. I have also been able to examine three perfectly typical specimens from the *Am. spinatus* Zone (Middle Lias) of the immediate neighbourhood of Banbury. One specimen was a fac-simile of Sowerby's figured type, and had been in the possession of Mr. Beesley's family for upwards of thirty years; he had likewise some few years ago picked up two blocks of the "dark greenish-grey limestone," containing several examples of Sowerby's species, and he had been able to trace them to a small quarry about two miles south of Banbury. Mr. Beesley informs me that the shell is now hardly ever met with in the neighbourhood of Banbury, but that it was, no doubt, abundant at the time Sowerby published his description of it, as the roads in the district were then mostly mended with the stone he described as the "Oxfordshire ironstone," which may have been obtained from quarries now long closed.

I have received a very instructive series of typical examples, some showing no indentation, from the Rev. F. Smithe, of Churchdown, who had obtained them from the *Am. margaritatus* and *M. spinatus* Zones of Churchdown, in Gloucestershire. It is

evident from the inspection of these specimens, as well as of those obtained near Banbury, that the indentation is not always present, or is at least an inconstant character. This fact is referred to by the Rev. F. Smithe in his important and instructive 'Memoir on the Middle Lias or *Am. spinatus* Zone of the north of Gloucestershire,' August 1877.[1] *W. indentata* occurs in Great Britain commonly at the top of the Middle Lias, and is found in a similar position in a great number of French localities, such as at Vieux Pont, Evrecy, and Fontaine-Etoupe-Four, Fontaine-le-Pesnel, &c., near Caen. It is also, according to Mr. Deslongchamps, a common fossil in the neighbourhood of Falaise, at Villy, Fresnay-la-Mère, and especially near Argentan (Orne).

This author refers Brocchi's *Anomia biplicata* ('Conchologia fossile Subapennina,' p. 469, pl. x, fig. 8, 1814) to the species under description; but, as some uncertainty still prevails with reference to the identification, he proposes that Sowerby's name *indentata* should be retained for the Liassic species, and *T. biplicata*, Sow., for the Cretaceous one—a view with which I entirely concur. He likewise states that part of Alcide d'Orbigny's *Ter. Sarthacensis* probably belongs to *W. indentata*, while the other portion constitutes a distinct species, which he describes as *T. Sarthacensis*, d'Orb., at p. 130 of his 'Brachiopodes Jurassiques.'

There can exist no doubt as to *W. indentata* being a true *Waldheimia*, as, in addition to its outward characteristics, Mr. Beesley has found a specimen showing the long loop peculiar to that genus (Pl. XXI, fig. 15).

Sowerby describes his species in the following manner:

"Elliptical, smooth, more or less gibbous; valves equally convex, front deeply notched, beak small, much incurved. In the young state this Terebratula, like others, shows but slight signs of a marginal notch; when full grown the notch is deep and obtuse angular; broad furrows extend from at about one third the length of each valve; its length is nearly twice its breadth. Found abundantly in dark greenish-grey limestone at Banbury and several other places. The two sides are not always equal." Sup., Pl. XXI, fig. 10, is from a drawing made from Sowerby's original specimen now in the British Museum.

[1] The Rev. F. Smithe observes that "the evidence afforded by the palæontology of the *Am. spinatus* zone (in north Gloucestershire and elsewhere) strongly bears out the statement that we here possess an example of an old sea-bottom of the mid-liassic epoch; and, also, that we are justified in assigning to it a definite position in the scale of depth. It formed a shelving shore of the division named by Professor Forbes the *Laminarian zone*, which would be about fifteen fathoms deep from the sea level. This position is shown by two distinct but associated groups of fossils. The first class of fossils would be the marine vegetation. . . . . They are the stems and other remains of Algæ of the olive group, which embraces the great sea-tangles. The stems are, where preserved, coriaceous in substance, showing no mid-rib, and only a blurred outline of organs of fructification. These particulars harmonise with my first account, and the evidence of them taken together is amply sufficient to lead us to place the depth of the *spinatus* beds in the *Laminarian* division of the liassic shore."

W. indentata appears to vary a good deal in shape, some examples being very little indented, and even almost straight in front, while others bear a certain degree of resemblance to *W. cornuta*. A specimen in Mr. Beesley's collection even shows a tendency to slight biplication.

139. Waldheimia emarginata, *Sow.* Dav., Ool. Mon., p. 35, Pl. IV, figs. 18—21; and Sup., Pl. XXIII, figs. 5, 6, 7.

Waldheimia emarginata, *Dav.* Proc. of the Dorset Nat. Hist. Field Club, pl. iii, figs. 10, 11, 1877.

Nothing new. It varies very considerably in shape, some examples approaching even to *W. cornuta*. It occurs in the Inferior Oolite at Broadwinsor, and in other places already recorded.

140. Waldheimia Waltoni, *Dav.* Ool. Mon., p. 36, Pl. V, figs. 1—3; and Sup., Pl. XXIII, figs. 8, 9, 10.

Terebratula emarginata and T. Bajociana, *D'Orb.* (pars). Prodrome, 1850 (according to Mr. E. Deslongchamps).

— — *Dav.* Proc. of Dorset Nat. Hist. Field Club, pl. iii, fig. 5, 1877.

I have nothing to add to the description I have given of this variable species beyond stating that large and fine examples have been found by Professor Buckman and Mr. Darell Stephens in the Inferior Oolite at Broadwinsor, and Bradford Abbas in Somersetshire and Dorsetshire. It occurs in the zones of *Am. Parkinsoni*, *Am. Humphresianus*, and *Am. Sauzei*. In France it is found in the same horizons, and in various localities, especially in Normandy. It has also been obtained from the Inferior Oolite near Wurtemberg, in Germany.

It is always very variable in shape. The smaller valve in some specimens is almost flat, in others slightly convex, also more or less elongated oval, and often very much thickened marginally.

A small variety of *W. Waltoni* (Sup., Pl. XXIII, figs. 9, 10) has also been found by Mr. J. F. Walker in the Inferior Oolite (*Rh.-cynocephala* bed) at Haresfield, Gloucestershire.

141. Waldheimia numismalis, *Lamarck*, sp. Dav., Ool. Mon., p. 36, Pl. V, figs. 4—9; and Sup., Pl. XXI, figs. 8, 9.

Waldheimia numismalis appears to have enjoyed a rather extended vertical stratigraphical range. It occurs in the Upper Zones of the Lower Lias (*Am. oxynotus* and *Am. raricostatus*), and is present throughout the whole range of the Middle Lias. Large specimens (completely flattened by compression), looking like old Roman coins, were found in vast abundance by Mr. J. F. Walker in the Lower Lias clay at the railway-cutting near the station, at Fenny Compton, in Warwickshire. The species has also been found by Rev. F. Smithe near Churchdown, in Gloucestershire. *Waldheimia cor*, Lamarck, an allied form, has not to my knowledge been hitherto discovered in British Liassic deposits, although Mr. E. Deslongchamps thought one of the specimens (Sup., Pl. XXI, fig. 9) might be referred to it. Judging from the figures of *W. cor* published by the last-named author in his 'Brachiopodes Jurassiques,' it varies considerably in shape and in the extent of the indentation of the frontal portion of its valves, as well as in the degree of their convexity. My distinguished friend observes likewise that some specimens are as flat as *W. numismalis*, while others have their valves very much more convex. After examining a great number of specimens of both species (?) it appeared to me that they merge wonderfully one into the other.

Although *W. numismalis* has its front line usually less indented than *W. cor*, still this distinction cannot be relied upon. Both present a depression in the anterior third of the length of the valves, although it is usually smaller in *W. numismalis*, and sometimes entirely absent. It is, therefore, a question demanding further consideration, whether *W. cor* is in reality more than a variety of *W. numismalis*. Fine examples of *W. numismalis* have been collected by Mr. Innes Griffin in the zone of *Am. Jamesoni* at Fenny Compton, in Warwickshire, in company with *Sp. oxyptera*, *Sp. verrucosa*, *Tereb. punctata*, *Rh. tetrahedra*, and *Lingula sacculus*.

142. Waldheimia sub-numismalis, *Dav.* Ool. Mon., p. 38, Pl. V, fig. 10; and Sup., Pl. XXI, figs. 1—7.

Terebratula (*Wald.*) sub-numismalis, *E. Desl.* Brachiopodes Jurassiques, p. 124, pls. xxvii, xxviii, xxix, 1863.

Shell subpentagonal, broadest posteriorly, nearly straight or very slightly indented in front; valves about equally deep and convex, but flattened near the front, and especially so in the ventral valve, the corresponding portion in the smaller valve forming

a gentle convex upward curve. Beak rather narrow, incurved, carinated, and truncated by a small circular foramen, separated from the hinge-line by a deltidium in two pieces; beak-ridges very sharply defined. Surface of valves smooth, and marked only by fine concentric lines of growth. Proportions variable; a large example (the type) measuring—

Length 1 inch 11 lines, width 1 inch 5 lines, depth 11 lines.

In 1851, when I proposed the name *sub-numismalis* for this species, I had seen but one specimen, and felt uncertain with respect to its distinguishing features. Since then several well-preserved and characteristic examples from the Marlstone or Middle Lias, of Chideock, near Charmouth, in the Museum of the School of Mines (Day Collection), as well as others collected in the same locality by Mr. J. F. Walker, in addition to the fine series of French examples figured by Professor E. Deslongchamps in the work above referred to, have convinced me that the shell deserves a specific designation. It varies considerably in shape. When quite young, and up to a certain age, it is almost circular, and but slightly elongated, but becomes more so with age; it is then longer than wide and longitudinally oval, by which character, in addition to the absence of a defined depression in either valve, and a nearly straight front, it may be easily distinguished from *W. numismalis*, *W. cor*, *W. quadrifida*, *W. cornuta*, and other allied forms. Some specimens are more convex than others. It was found by the Rev. F. Smithe in the Middle Lias (Zone of *Am. margaritatus* at Churchdown, Gloucestershire, Sup., Pl. XXI, fig. 4). It also occurs in the Marlstone at South Petherton, Somerset, where it is rare.

In France it is, according to Mr. E. Deslongchamps, a common fossil at May, Fontaine-Étoupe-Four, Bretteville-sur-Laize, and other places in Normandy.

143. Waldheimia Darwini, *E. Desl.* Sup., Pl. XXIV, figs. 9, 10, 11.

Tebebratula (*Waldhemia*) Darwini, *E. Desl.* Brachiopodes Jurassiques, p. 128, pl. xxx, figs. 1—10, 1863.

Shell small, much compressed, either as wide as long and truncated in front, or longitudinally oval and rounded in front. Valves not very convex, that of smaller valve often depressed or flattened along the middle. No fold nor sinus; beak incurved and perforated by a small circular foramen, slightly separated from the hinge-line by a narrow deltidium, beak-ridges sharply defined. Surface smooth. Dimensions of two specimens:

Length 7, width 7, depth 4 lines.
„ 6, „ 5, „ 3 „

Obs.—In 1851, during a visit to Radstock, I picked up in the Middle Lias, at Clandown quarry, several examples of a small flattened *Waldheimia*, which I was unable to refer to any species with which I was then acquainted, and it was only last year, during Mr. Deslongchamps' visit to Brighton, that I was informed that this small shell was referable to his *T.* (*W.*) *Darwini*. In his description of this shell he states that it is a badly defined species, and so variable that it is difficult to assign to it any typical form; such is truly the case with our English examples, and I was glad to have at last some name to give it. With us it does not appear to have much exceeded the dimensions above given. In France it was found by Professor E. Deslongchamps in the Middle Lias at May and Bretteville-sur-Laize, in Normandy.

144. Waldheimia perforata, *Piette*. Sup., Pl. XXIV, figs. 1, 2, 3, and 5 ?.

Terebratula marsupialis, *Zieten*. Die Verst. Württemb., p. 53, tab. xxxix, fig. 9 (not *T. marsupialis*, Schloth., 1819).

— perforata, *Piette*. Bull. Soc. Géol. de France, 2nd ser., vol. xiii, p. 188, pl. x, fig. 1, 1856.

— psilonoti, *Quenstedt*. Der Jura., p. 48, tab. ix, fig. 21, 1856.

— strangulata, *Martin*. Paleont. stratig. de l'Infra-lias de la Bourgogne, Mém. Soc. Géol. de France, 2nd ser., t. vii, p. 9, pl. vii, figs. 8—10, 1860.

— perforata, *Oppel*. Über die Brachiopoden der unteren Lias, p. 531, 1861.

— — *Hebert*. Bull. Soc. Géol. de France, 2nd ser., vol. xix, p. 102, 1861.

— — *R. Tate*. Geol. Mag., vol. vi, Dec., 1869.

— — *E. Deslongchamps*. Brach. Juras., p. 73, pl. ix, figs. 1—5, pl. xxiii, figs. 1—3, 1863.

Waldheimia Sarthacensis (part), *R. Tate*. The Yorkshire Lias, p. 418, pl. xv, figs. 10, 11, 1876.

Shell longer than wide, sub-pentagonal, valves almost equally deep, without fold or sinus, and somewhat flattened; truncated, or straight in front; ventral valve moderately convex; beak tapering, slightly incurved, and truncated by an oval foramen separated from the hinge-line by a deltidium in two pieces; beak-ridges sharply defined; dorsal valve gently convex, with sometimes a slight depression near the front; surface smooth; loop long.

Length 13, width 9, depth 6 lines.

Obs.—At p. 418 of the 'Yorkshire Lias,' Mr. R. Tate observes that "whatever name the species should receive, there is no doubt that it has long been known in this country, having been confounded with *T. ornithocephala* by Sowerby as early as 1815, and by

Portlock in 1843, and in later years more frequently with *T. punctata*." The specimen of the so-termed *T. ornithocephala*, 'Min. Con.,' Tab. 101, fig. 4, from the Blue Lias Marl of Pickeridge, evidently belongs to *W. perforata* of Piette; and I prefer to refer it to that species, as D'Orbigny's *Ter. Sarthacensis* is involved in some confusion, and none exists with respect to Piette's species. It is very questionable whether the true *W. Sarthacensis* of D'Orbigny has been found in our Liassic strata. *W. perforata* is remarkable for its sub-pentagonal shape and small umbo; and, as stated by Mr. R. Tate, it is nearly allied to *W. indentata*, although specifically separable. Dr. Wright quotes it under the name of *T. psilonoti* (Quenstedt) in his paper "On the Zone of Avicula Contorta, and the Lower Lias of the South of England" ('Quart. Journ. Geol. Soc.,' vol. xvi, p. 403, 1860), and from the zone of *Am. Bucklandi*. Professor R. Tate mentions its occurrence in the zone of *Am. angulatus* (a portion of the Hettangian Series of French Liassic Geologists) at Market Weighton and Redcar. It was also found in a similar position by the Rev. F. Smithe, near Churchdown, in Gloucestershire. Much credit is due to the Rev. F. Smithe for having been able to isolate this zone, which had been often classed by British geologists with either the *Am. planorbis* or *A. Bucklandi* zone. The *Am. angulatus* zone, near Churchdown, has afforded the Rev. F. Smithe between seventy and eighty species. *W. perforata* has also been found in the Middle Lias (zone of *Am. Jamesoni*), at Huntcliff, Coatham, Normandy, Upsall, and Easby, and in the *A. spinatus* zone at Grosmont, Yorkshire (Tate). The same author quotes it from the *Am. armatus* zone of Robinshood Bay (Yorkshire). It has been found likewise near Radstock, near Bristol, Bath, Stonehouse, Charmouth, and in many other places. It occurs in the *Am. Bucklandi* beds at Hallaig, in the Island of Raasay, Scotland (Tate); and it is very abundant in the same horizon in France, also in Wurtemberg.

Waldheimia ornithocephala, W. lagenalis, W. Cadmonensis, W. lampas.

In August, 1815, James Sowerby published his description of *Terebratula ornithocephala* in the following words: "Ovato-rhomboidal; depressed when young; elongated and gibbous when old; front straight, bounded by two obtuse lateral depressions similar in each valve. The aperture in the elongated beak is large. Breadth of shell equal to four fifths of its length; the sides, being rather depressed, produce an obtuse angular projection on the front. I have specimens from the Cornbrash Limestones at Chatley from Thomas Meade, Esq., and others picked out of the Blue Lias (Marl) at Pickeridge, by favour of Miss Hill. The left-hand figure is from a Cornbrash Limestone specimen, and figure 4 is a young depressed shell from Pickeridge."

Sowerby, however, seems to have confounded two or three species under his designation of *T. ornithocephala*. The type fig. 1 (Sup., Pl. XXII, fig. 1) is stated to be from the Cornbrash ; figs. 2 and 4 from the Blue Lias. I obtained from the late Mr. J. de C. Sowerby the loan of the three original specimens figured in Tab. 101 of the 'Min. Con.' (now in the British Museum), and was able not only to compare them attentively, but to make faithful drawings which will be found reproduced in my plates. Of the three figures attributed by Sowerby to *T. ornithocephala*, fig. 1 is stated to be from the Cornbrash and derived from the same locality as *T. obovata*, fig. 5 of same plate. Figs. 2 and 4 are labelled from the Blue Lias, and are of a greenish colour. Fig. 2 has been with some uncertainty referred by Mr. E. Deslongchamps to *Ter. punctata ;* and fig. 4 by Mr. R. Tate to *T. Sarthacensis*, but surely not to d'Orbigny's species, for that palæontologist, at p. 258 of his 'Prodrome' (vol. i, 1847), quotes it in the following manner :

"*Terebratula Sarthacensis*, d'Orb. 1847 = *T. ornithocephala*, Sow., pl. 101, fig. 5 (exclus., figs. 1, 2), and no mention is made of fig. 4 ; therefore, according to d'Orbigny, *T. Sarthacensis* would be a synonym of *T. obovata*. The specimens of *Sarthacensis* in that author's collection, at the Jardin des Plantes, do not belong to the Cornbrash species, and it is therefore probable that he had fig. 4 in view as the type of his species. Prof. Tate may be nearer the mark when he refers fig. 4 of 'Min. Con.' to *T. perforata*, Piette ; but he is not quite correct when stating, at p. 418 of the 'Yorkshire Lias,' that Sowerby's *T. ornithocephala*, pl. 101, fig. 5, comes from the Blue Liassic Marls of Pickeridge Hill, south of Taunton ; and he no doubt intended to say fig. 4, as fig. 5 unquestionably belongs to *T. obovata*. Mr. Tate is again mistaken when he supposes that my figure ('Ool. Mon.,' Pl. V, fig. 16) was intended to represent fig. 4 of the 'Min. Con.' In the description of the figure I said, "from one of the original specimens of *T. obovata* in Sowerby's collection." If Mr. Tate had referred to my description of *T. obovata* he would have found that I did not quite overlook the original type fig. 5, to which I alone refer.

In 1816, in his 'Strata Identified' Smith figures a Terebratula from the Kelloway Rock under the name of *T. ornithocephala*, Sow., with locality Dauntsey House, Thames and Severn Canal, near Chippenham, and this may, perhaps, be referable to *W. umbonella*. *W. ornithocephala* occurs abundantly, and in a fine state of preservation, in the Fuller's earth Oolite in England, as well as on the Continent ; and it is from that rock that the most characteristic and abundant specimens of the species have been derived.

As stated elsewhere, *T. triquetra*, Sow., is only a slightly indented variety of *W. ornithocephala*. *W. lagenalis*, *W. sublagenalis*, *W. umbonella*, *W. lampas*, and *W. Cadmonensis* are, according to Mr. E. Deslongchamps, distinct species. Their distinguishing characters are, however, sometimes difficult to define, and many passage-forms can be procured by which they may be connected to a greater or lesser extent, especially by half-grown specimens.

145. Waldheimia ornithocephala, *Sow.* Dav., Ool. Mon., p. 40, Pl. VII, figs. 6, 7, 8, 10—13, and 23; Sup., Pl. XXII, figs. 1, 2; Pl. XXIV, fig. 27.

Terebratula ornithocephala, *Sow.* Min. Con., tab. ci, figs. 1, 2 (?), (not 4), 1815.
— triquetra, *Sow.* Min. Conch., tab. ccccxlv, fig. 1, 1821.
— ornithocephala, *Dav.* Proc. of the Dorset Nat. Hist. and Antiquarian Field Club, pl. iii, figs. 12, 13, 1877.

With the help of Sowerby's description and the one I have given at p. 40 of my Monograph the student will have a correct idea of the shell we retain as the type of the species. It is very variable in shape, smooth, usually longer than wide, ovate-rhomboidal, broadly rounded posteriorly, laterally and anteriorly more or less pinched in, and nearly straight in front. Valves moderately convex, without fold or sinus, but flattened along the middle, and somewhat abruptly sloping away laterally so as to leave two more or less defined diverging lines on the surface of both valves; the beak is much incurved, the small circular foramen slightly overlies the foramen of the opposite valve, but usually leaves a small space for the deltidial plates between it and the hinge-line; loop long. When adult the shell measures 1 inch 8 lines in length, by 1 inch 1 line in breadth and 10 lines in depth, but it is usually smaller. Some specimens which have been referred to this species are almost spherical, with both valves very convex, but these cannot be taken as indicating the average shape of the shell.

Fine typical examples of *W. ornithocephala* have been found by Mr. J. F. Walker in the cutting through the Fuller's earth rock at Bruton Railway-station, Somersetshire. Mr. E. Deslongchamps considers *W. ornithocephala* to be a tolerably well-defined species occurring only in the Fuller's earth; but I very much doubt its being so localised; and at any rate Mr. Sowerby mentions having found it in the Cornbrash together with *W. obovata*. Mr. Darell Stephens also collected characteristic specimens in the Inferior Oolite at Milborne Wick, near Bradford Abbas; but in this instance the stratum may perhaps have been Fuller's earth rock.

Waldheimia ornithocephala occurs also round Nunney and between Whatley and Frome in the Fuller's earth rock. These specimens and those from Bruton are of a yellowish colour. It is also found at Box Tunnel, near Bath, where the specimens are of a blue colour arising from the nature of the matrix. From this place, perhaps, Sowerby's fig. 2 may have been derived, and by mistake referred to Blue Lias; for in the Fuller's earth Oolite of this last-named locality all the specimens are of a bluish colour, while the shell is brown in the same rock of other places, and elsewhere, again, of a light yellowish tint, always due to the nature and colour of the matrix. A variety of *W. ornithocephala* resembling *W. obovata*, or its variety *Stiltonensis*, occurs sparingly

in the Callovian formation, and in the Museum of the School of Mines in London there are some examples of the var. *Calloviensis* (Sup., Pl. XXVI, figs. 28, 29), from the Kelloway Rock of Kelloway. This form also occurs, according to Mr. E. Deslongchamps, in beds characterised by *Ammonites bullatus* and *Am. modiolaris*, at the hillock of Escoville, at Tannerville, and at other localities in the Kelloway Clay of France.

146. Waldheimia lagenalis, *Schlotheim*, sp. Dav., Ool. Mon., p. 42, Pl. VII, figs. 1—4, 14.

Terebratulites lagenalis, *Schlotheim*. Petrefacta Germ., 1820.
— sub-lagenalis, *Dav.* Ool. Mon., p. 42, pl. vii, fig. 14, 1851.

I have very little to add to the description I have already published of this species (?) It differs from *W. ornithocephala* in having its lateral sides almost straight, and not pinched in anteriorly, as is usually the case in the last-named species. It is also a larger shell, more elongated, somewhat thicker, and with a more incurved beak and smaller foramen. The smaller valve is more globose, straight, or slightly indented in front. When presenting the last-named peculiarity it forms the variety I proposed to name *sublagenalis*.

In his notes "Sur le Terrain callovien" ('Bull. Soc. Linn. de Normandie,' vol. iv, 1859) Mr. E. Deslongchamps proposes to retain *W. lagenalis* and *W. sublagenalis* as distinct species, but I feel certain that the specimens upon which I proposed to found the variety are only indented examples of Schlotheim's species. Some abnormal forms of *W. lagenalis* have been referred to *W. ornithocephala*.

W. lagenalis, as we have elsewhere remarked, abounds in the Cornbrash of Boulogne-sur-Mer, where some examples have attained fully two inches in length by one in width. In England both *W. lagenalis* and the so-termed *sublagenalis* occur together in the Cornbrash of several localities, and in a perfect state of preservation. Messrs. Walker and Hudleston state that the species is common in the Cornbrash of Scarborough, and that it occurs also in the *Avicula*-shales.

147. Waldheimia umbonella, *Lamarck*, sp. Sup., Pl. XXII, figs. 7, 8.

Terebratula umbonella, *Lamarck*. Anim. sans Vert., t. vi, p. 249, 1819; and *Dav.* Examination of Lamarck's species of fossil Terebratulæ, Annals and Mag. of Nat. Hist., 2nd ser., vol. v, pl. xiii, fig. 18, 1850.
— — *Deshayes*. Ency. Méth., vol. iii, p. 1028, pl. ccxl, fig. 5, 1832.

Terebratula	Royeriana, *d'Orb.*	Géol. de la Russie d'Europe, vol. ii, 3rd part, pl. xlii, figs. 33—38, 1845.
—	—	*Guéranger.* Répert. Paléontol. de la Sarthe, p. 24, 1853.
—	—	*Cotteau.* Études Moll. Foss. de l'Yonne, p. 135, 1857.
—	—	*Oppel.* Die Jura-Form., p. 571, 1857.
—	umbonella,	*E. Deslong.* Bull. de la Soc. Linn. de Normandie, t. iv, p. 242, 1859.
—	—	*E. Deslong.* Mém. de la Soc. Linn. de Normandie, vol. xi, 1859.
Waldheimia	—	*J. F. Walker.* Geol. Mag., p. 572, 1875.

We are indebted to Mr. J. F. Walker for the discovery of this species? or variety of *W. lagenalis* in the Kelloway Rock of Scarborough Castle Hill.[1] When, in 1850, I was examining Lamarck's species of fossil *Terebratulæ,* I was struck with the strong resemblance between *T. umbonella* and certain specimens of Schlotheim's species. I then stated "one specimen shows the deltoidal area, while in others the umbo of the ventral valve touches the beak; this is visible in our specimens of *T. lagenalis.*" I think it, however, if not a distinct species, at any rate a well marked variety. This seems to be likewise the opinion of Mr. E. Deslongchamps, although he retains it as a distinct species. He observes "cette espèce, connue depuis long-temps, varie un peu dans sa forme plus ou moins allongée, plus ou moins comprimée, plus ou moins bombée vers les crochets. Elle se rapproche beaucoup des *Ter. lagenalis* et *ornithocephala,* dont elle se distingue par sa forme plus arrondie et plus régulièrement convexe. Très caracteristique des couches moyennes du Callovien, elle a été souvent observée; d'Orbigny et, d'après lui, beaucoup de Géologues l'ont cité sous la dénomination de *Ter. Royeriana;* mais, outre qu'elle avait un nom depuis long temps, elle a été confondue par d'Orbigny avec la *Ter. biappendiculata,* comme j'ai pu m'en assurer en visitant sa collection."

This species replaces in the Kelloway Rock the *W. lagenalis* of the Cornbrash. In the Boulonnais it occurs at the base of the Oxfordian series, where it was found in great abundance by Mr. Bouchard. Mr. Deslongchamps states it to be very common in the ferruginous beds of the Callovian at Montbizot, at Balon, and Beaumont (Sarthe); at the hillock of the Bois d'Auge and Exmes (Orne), &c.; at Koroskovo, near Moscow, and Orembourg (Russia).

148. Waldheimia lampas, *Sow.*, sp. Sup., Pl. XXII, figs. 3, 4, 5, 6.

Terebratula	lampas, *Sow.*	Min. Con., tab. ci, fig. 3, 1815.
Waldheimia	—	*J. F. Walker.* Geol. Mag., p. 574, 1876.

At p. 41 of my 'Oolitic Monograph' I stated that "*Terebratula lampas* is merely an

[1] 'On the Distribution of the Brachiopoda in the Oolitic Strata of Yorkshire;' Communications to the Monthly Meetings of the Yorkshire Phil. Soc., 1877. Mr. Walker states that this variety of *W. ornithocephala* is thicker than the last-named species from the Fuller's Earth Rock.

internal cast of *Ter. ornithocephala :*" but this may be a mistake. In 1850 I had only seen the internal cast figured by Sowerby, of which I now append a careful drawing made from the original specimen (Sup., Pl. XXII, fig. 6) now in the British Museum. Since that period I have been able to examine a large number of specimens obtained by Mr. J. F Walker from the Supra-coralline beds or red ferruginous rock at Abbotsbury in Dorsetshire. After careful comparison of these (Sup., Pl. XXII, figs. 3, 4) with examples of *W. ornithocephala* (Sup., Pl. XXII, fig. 1), I was able to detect very little difference between many of the specimens. Some of them, however, presented a small longitudinal depression at the umbone, not observable in *W. ornithocephala*, and the shell is likewise less pinched in laterally and anteriorly, the smaller valve flatter and the beak more incurved.

Mr. Deslongchamps admits that he was mistaken when he supposed this species to be the internal cast of *W. cornuta*, to which it bears no resemblance. He observes, moreover, that it is a form very abundant in the Oxford Clay of the East of France, also in the Argile de Dives, Normandy, and that he had always considered it as a variety of *T. bucculenta*. He adds that in d'Orbigny's collection, in the Museum of the Jardin des Plantes, this species also bears the name of *T. Royeriana*, and is mixed up with specimens of *W. umbonella*.

The Abbotsbury examples of *W. lampas* are of a brown ochreous colour, due to the ferruginous nature of the matrix. Sowerby's figure is also of a red-brown colour, and some information may be obtained from the colouring of the plates with regard to the rocks from which that author's specimens were derived. Mr. J. F. Walker informs me that the Abbotsbury specimens come from near the spot whence the internal cast figured by Sowerby was obtained. According to Mr. D. Stephens *W. ornithocephala* first occurs in the Inferior Oolite ; but it is a most abundant and characteristic fossil of the Fuller's Earth. *Wald. lagenalis* abounds in the Cornbrash ; *W. umbonella*, a variety of *ornithocephala*, in the Kelloway Rock ; and *W. lampas* in the Supra-coralline bed : these are all closely allied forms, perhaps descended from a common ancestor.

149. Waldheimia Cadomensis, *E. Desl.*, sp. Dav., Ool. Mon., Pl. VII, figs. 6 and 9 ; and Sup., Pl. XXII, fig. 9, and Pl. XXIV, figs. 14, 15.

Terebratula ornithocephala, *Dav.* (pars). Ool. Mon., pl. vii, figs. 6 and 9, 1851.
— (*Wald.*) Cadomensis, *E. Desl.* Description des Couches du Système Oolitique Inférieur du Calvados ; Bull. Soc. Linn. de Normandie, vol. ii, pl. iv, figs. 3, 4, 1857.

Shell elongated oval, widest posteriorly, tapering anteriorly, straight in front ; valves nearly equally deep, very convex, especially at the umbo of the dorsal valve, sometimes

slightly depressed along the middle to a short distance; ventral valve somewhat carinated; beak much incurved, and truncated by a small circular foramen very slightly separated from the hinge-line by small deltidial plates; beak-ridges sharply defined; surface smooth, marked by numerous strong concentric lines of growth. Length 16, width 11, depth 11 lines. Young specimens are elongated oval. (Sup., Pl. XXIV, figs. 14, 15).

Obs.—Mr. E. Deslongchamps considers this shell to be specifically distinct from *W. ornithocephala.* In England it occurs, with *W. ornithocephala,* in the Fuller's Earth Oolite of Powerstock, near Bridport, and in the Inferior Oolite of Charlcombe, near Bath. Mr. Deslongchamps states that the species is very abundant in the White Oolite near Caen, and that it is likewise found in the Fuller's Earth and Inferior Oolite in Calvados, Sarthe &c. Some specimens seem nearly allied to *W. ornithocephala.*

Waldheimia obovata, W. digona, and W. bucculenta.

These three species seem to be so intimately related as to form a small group, to which might be added several others, not only from the Jurassic rocks, but likewise from the Cretaceous strata.

150. Waldheimia obovata *Sow.*, sp. Dav., Ool. Mon., p. 39, Pl. V, fig. 14—17, and Pl. VII, fig. 5; Sup., Pl. XXII, figs. 10, 11.

Terebratula digona, var. *Smith.* Strata Identified, p. 26, pl. ix, Cornbrash. (Not *T. digona,* Sow.) 1816.

Waldheimia obovata, *Walker and Hudleston.* Communications to Monthly Meetings of the Yorkshire Phil. Soc., 1877.

Since describing this species at p. 39 of my Monograph, Mr. J. F. Walker has obtained a large number of finely preserved specimens from the Cornbrash of Yaxley or Stilton, near Peterborough, also from Cirencester. He has been able to point out two or three tolerably persistent varieties, which he considers desirable to characterise by distinctive denominations.

The typical form (Ool. Mon. Pl. V, figs. 14—16; and Sup., Pl. XXII, fig. 10) is more or less sub-pentagonal, almost as wide as long, with a wide straight front. Some malformations show a tendency to rudimentary plications along the frontal line, but these folds do not extend to any distance on either valve. Some examples (Sup., Pl. XXII, fig. 10) become very convex, so as to almost simulate *T. sphæroidalis.* For this last named variation Mr. J. F. Walker proposes the subordinate designation *perobovata.* In addition

to the localities already recorded, Mr. J. Parker found many fine example of this species in the Cornbrash of Kidlington Pit, east of the railway beyond Woodstock Road Station ; also at Bicester, and at the Langford Lane Pit and Combe Pit, about two miles west of Hanborough Station, near Oxford. Prof. Prestwich furnished me with many fine examples from the same localities from the Oxford Museum. Mr. James Parker states that he has found *W. obovata* in the Oxford Clay of St. Clements, Oxford. I have seen the specimens, which certainly belong to the species, but I feel surprised at their geological position.

151. Var. *Siddingtonensis*, Walker MS. Sup., Pl. XXII, figs. 12, 13, 14.

This variety is much more elongated, and has been sometimes mistaken for *W. digona* Specimens of a yellow colour from the Cornbrash of Siddington, near Cirencester, simulate that species. It occurs likewise at Yaxley, near Peterbro', and at Stanton, in Wiltshire. It has been found in the Cornbrash near Scarborough, and by Mr. Bell in the same formation at Burton Hill, near Malmsbury.

152. Var. *sub-obovata*, Walker MS. Sup., Pl. XXII, figs. 15, 16.

This shell is, to all appearances, consistent in shape in both large and small specimens, and consequently, perhaps, deserving of a distinctive designation. It is wedge-shaped and broadly rounded laterally, as well as in front ; almost as broad as long ; with valves about equally deep, moderately convex and flatter ; the edges of the valves are sharper than in the typical form ; the beak is very slightly convex ; foramen small, and separated from the hinge-line by a deltidium in two pieces. It occurs abundantly associated with *T. intermedia* in the Cornbrash of Yaxley, near Peterborough, and at Kidlington, near Banbury, in Oxfordshire.

153. Var. *Stiltonensis*, Walker MS. Sup., Pl. XXII, figs. 17, 18, 19, 20.

This variety is very much pinched in laterally near the front, and closely resembles *W. bucculenta*. It is longer than wide, and often very much thickened at the margin. It occurs in the Cornbrash at Stilton. The late Mr. Leckenby found it in the Cornbrash near Scarborough.

This variety of *W. obovata* has often been called *W. ornithocephala*, var. in lists of Cornbrash fossils. Mr. E. Deslongchamps states, in his description of *W. obovata*, that it approaches by its general shape *W. digona*, but that it can be distinguished by its much more convex valves, that its beak is more carinated laterally, and that it is the passage-form between *W. digona* and *W. ornithocephala*.

Several curious malformations of this species have been found, some showing a lobed condition, approaching that in the group of *T. diphya*.

154. Waldheimia digona, *Sow.*, sp. Dav., Ool. Mon., p. 38, Pl. V, figs. 18—24; and Sup., Pl. XXII, figs. 21, 22.

Nothing new, with the exception that Mr. Walton found a specimen showing long spines rising from the outer edge of the principal branches of the loop, as may be seen in the figure we have added to this Supplement. Here, also, as in *W. obovata*, we meet with exceptionally shaped specimens, in which the front line, instead of being straight, is convex and rounded, or sometimes even indented. It occurs in the Great Oolite and Bradford Clay at Bradford, and at Tetbury Road Station. Mr. Darell Stephens found it in the Bradford Clay, associated with *Rh. Boueti* and a small var. of *T. intermedia*, at Burton, Bradstock.

155. Waldheimia bucculenta, *Sow.*, sp. Dav., Ool. Mon., p. 55, Pl. XIII, fig. 8; and Sup., Pl. XXII, fig. 23; and Pl. XXIV, figs. 23, 24, 25.

I have but little to add to the description I have already published of this variable species. Mr. J. F. Walker has been able to settle its stratigraphical position in the passage-bed of the Lower Calcareous Grit of Appleton-le-Street, four miles from Malton, in Yorkshire. He has also found it at Filey in the same horizon. A black line along the umbone of the smaller valve indicates that it is a *Waldheimia*. This species is associated with *W. Hudlestoni*, *Ter. Fileyensis*, and *Rh. Thurmani*. *W. bucculenta* occurs also in the Elsworth Rock. Specimens of this fossil from that deposit may be seen in the Woodwardian Museum, Cambridge, and one was obtained by the late Mr. Leckenby from the Cornbrash of Scarborough (Sup., Pl. XXIV, fig. 23), which I cannot distinguish from some of the varieties of the shell under description. It is not, however, always an easy matter to distinguish some exceptional forms of *W. bucculenta* and *W. obovata*, var. *Stiltonensis*, which seem to be closely allied; it is therefore possible that this Cornbrash specimen may be an extreme form of the variety *Stiltonensis*.

W. bucculenta has been found by Mr. Rigaux in the Oolite Corallienne d'Herdin l'Abbé, near Boulogne-sur-Mer, also at the Mont des Boucardes. During a recent visit to Cambridge Mr. E. Rigaux examined the Elsworth Rock and recognised it as the equivalent of his Calcaire d'Houllefort, the stratigraphical position of which is immediately above the Oxford Clay bed containing *Wald. impressa* and *Terebratula insignis*. This

last species neither in France nor in England attains the dimensions of specimens occurring in deposits of about the same age in Germany, but they nevertheless show all the characters of the species.

Brachiopoda seem to be rare both in the Elsworth Rock and its equivalent in France, for I am only acquainted with the two species above recorded from this deposit.

156. Waldheimia Waterhousi, *Dav.* Ool. Mon., p. 31, Pl. V, figs. 12, 13.

Terebratula (*Wald.*) Waterhousi, *E. Desl.* Brach. Jur., p. 103, pl. xxi, figs. 1, 6, 1863.

This species was described and figured by Oppel in his 'Der mittlere Lias Schwabens,' p. 71, tab. iv, fig. 2, under the designation of *T. subdigona*. Mr. E. Deslongchamps is of opinion that it may be the *T. lunaris* of Schubler in Zieten's 'Die Versteinerungen,' p. 59, pl. xliv, fig. 4. As, however, Zieten's figure does not entirely recall the species under description, I have preferred, at least provisionally, to retain the specific denomination of *Waterhousi*, which has been so generally adopted. It is a very characteristic species of the Middle Lias, and, according to Prof. R. Tate, occurs especially in the zones characterised by the *Am. ibex*, *A. capricornus*, and *A. spinatus*. It has been found in nearly all the quarries round Radstock, and also in the Middle Lias of Wellington Cutting on the new line from Lincoln to Grantham. This species is the *Ter. retusa* of Martin ('Pal. de l'Infra-Lias de Dép. Côte d'Or, Mém. de la Soc. Géol. de France,' 2nd ser., vol. vii, p. 90, pl. vii, figs. 5, 6, 7, 1860). *W. Waterhousi* has been well described and figured by Mr. E. Deslongchamps at p. 104 of his 'Brachiopodes Jurassiques,' where he observes that, though at once participating in all the characters of *W. cornuta* and *W. Heyseana*, it can yet be distinguished from both. It occurs in the Middle Lias of Fontaine-Etoupe-Four, and in several other localities in Normandy. In Germany it is abundant in Wurtemberg and Bavaria: also in the Tyrol.

157. Waldheimia Hughesi,[1] *Walker, MS.*

Shell ovate, longer than wide, sides and front rounded, sometimes slightly pinched in laterally and posteriorly. Valves nearly equally deep and regularly convex, without fold or sinus; beak much incurved, and truncated by a small circular foramen slightly overlying the umbone of the opposite valve. Surface smooth. A dark line on the smaller valve shows that the loop is long. Two specimens measured—

[1] The figure of *W. Hughesi* has been inadvertently omitted from the Plate.

Length 10, width 7, depth 6 lines.
„ 9, „ 8, „ 6 „

Obs.—I have seen five specimens of this species, collected by Mr. J. F. Walker from the Lower Trigonia-grit (Inferior Oolite) at Leckhampton Hill, near Cheltenham. These specimens varied a good deal in shape, some being comparatively shorter than others, and somewhat pinched in laterally in the anterior half of the shell. Mr. Walker has named this species after his friend Prof. Hughes, of Cambridge.

158. Waldheimia Lycetti, *Dav.* Ool. Mon., p. 44, Pl. VII, figs. 17—22; Sup., Pl. XXIV, figs. 30, 31.

This well-marked and interesting species occurs in the lower portion of the Upper Lias, or in the zones of *Am. communis*, *A. bifrons*, and *A. jurensis*. Mr. E. Deslongchamps describes it at great length at p. 183 of his 'Brachiopodes Jurassiques.' He observes that it is very constant in shape, and is of great geological importance on account of its stratigraphical position in the lower portion of the Upper Lias, where species of *Waldheimia* and *Terebratula* are very rare. He adds that it occurs in the lower beds of the Upper Lias in France. It is found in England also at the same horizon, and is the only form quoted from the Upper Lias by Prof. R. Tate in his paper on the 'Brachiopoda of the British Liassic Formations.' In Normandy it makes its first appearance in the Marls of the Upper Lias, characterised by *Am. bifrons* and *Am. Thouarsensis*, and acquires a larger size in the zone of *Am. opalinus*. The last appearance of this species is, as far as we know, in the Infra-Oolitic Marls with *Am. Murchisoni* and *Am. Sowerbyi*. It occurs also at Fontaine-Etoupe-Four and in several other localities. *W. Lycetti* was for the first time collected from the Upper Lias of Barrington, near Ilminster. It is also quoted by the Rev. F. Smithe in his valuable memoir 'On the Geology of Churchdown Hill,' read before the Cotteswold Naturalist Club in August, 1861, from the zone of *Am. communis* at Churchdown, where, according to the same authority, it is accompanied by *Rh. pygmæa*, *Ter. globulina*, *W. numismalis*, *Spiriferina Munsteri*, *Sp. Ilminsteriensis*, *Leptæna Moorei*, and *L. Liasiana*. Messrs. Beesley,[1] Griffin, and Walford, of Banbury, have quite recently picked up a great number of fine large examples (Sup., Pl. XXIV, figs. 30, 31) in a railway-cutting at Bloxam, near Banbury, in Oxfordshire (Banbury and Cheltenham line). The rocks belong to the *Am. communis* zone of the Upper Lias, the Cephalopod beds of the locality being the great feature of the section. Along with the species under description the gentlemen above named found in the same bed *Ter. punctata*, *Rh. tetrahedra*, *Rh. jurensis*, *Rh. Bouchardii*, and a smaller species of the same genus. A *Spiriferina*, not complete enough for identification, was also found with the fossils

[1] Mr. Beesley has ascertained that *W. Lycetti* in the Banbury district does not occur higher up than the *Am. serpentinus* zone, and is usually accompanied by *Rh. jurensis*.

above named. According to Mr. Walford *W. Lycetti* occurs, likewise, in the Upper Lias of Byfield, in Northamptonshire.

Waldheimia Lycetti varies a good deal in shape as well as in dimensions. The largest specimen I was able to examine measured-length 9, breadth 9, depth 5 lines. It is often somewhat marginally square, with rounded angles, the hinge-line being long; the beak small and perforated by a minute circular foramen. It varies likewise to a considerable extent in the degree of convexity of its valves; the ventral valve is always the deepest. In some examples the valves seem almost uniformly convex without any fold or sinus, in others the dorsal valve is nearly flat and front line straight, but in the larger number of individuals there exists a median depression, commencing at about half the length of the valve and extending to the front, while in a few, the reverse seems to be the case, for there exists, in place of the concave depression, a slight elevation simulating a mesial fold. The species is, however, easily recognisable in its various modifications and seems characteristic of the deposit in which it occurs.

159. Waldheimia Dorsetensis, *Walker*. Sup., Pl. XXIV, figs. 6, 7, 8.

Waldheimia Dorsetensis, *J. F. Walker*. Geol. Mag., New Ser., vol. iii p. 574, 1876.

Shell somewhat sub-pentagonal, broadest posteriorly, tapering anteriorly, nearly straight in front; as broad as long or slightly longer than wide; ventral valve much deeper than the dorsal one and carinated along its middle; beak large, very much incurved, and truncated by a small circular foramen overlying the umbone of the opposite valve. Dorsal valve slightly convex, sometimes a little depressed along the middle. Surface of valves smooth and marked only by a few concentric lines of growth; loop long. Two specimens measured—

Length 10, width 9, depth 6 lines.
" 8, " 8, " 5 lines.

Obs.—*Waldheimia Dorsetensis* was found by Mr. J. F. Walker in great abundance in the Supra-Coralline bed at Abbotsbury in Dorsetshire, associated with *Wald. lampas*, *Ter. subsella*, and *Rh. pinguis* var. *pectunculoides*. The rock is of a red ferruginous colour, of which the fossils partake.

160. Waldheimia margarita, *Oppel*. Sup., Pl. XXIV, figs. 12, 13.

Terebratula (*Wald.*) margarita, *Oppel*. Ueber die weissen und rothen Kalke von Vils in Tyrol; Württemb. Naturw. Jahreshefte, Jahrgang XVII, p. 35, tab. ii, fig. 3, 1861.

Shell small, smooth, subpentagonal, straight in front: valves nearly equally convex and often thickened at the margin, without fold or sinus; beak much incurved, and truncated by a small circular foramen slightly separated from the hinge-line by a short deltidium, beak-ridges sharply defined.

Length 6, width $5\frac{1}{2}$, depth 4 lines.

Obs.—This small and well-marked species, as justly observed by Dr. Oppel, so closely resembles *Wald. tamarindus* from the Neocomian, that it would be difficult to point out in what they differ! Although specimens of the shell from the Coral Rag of Calne have been in my possession since 1853, it is only recently that the fossil was recognised, by the Rev. J. F. Blake, as a British species. He found specimens agreeing with those from Vils in the Coral-rag of Hilmarton, and Mr. Hudleston found it at Faringdon. It has also been recently discovered by Mr. Walker in the Coral-rag of Seames in Yorkshire. We have therefore now recorded from four British Coral-rag localities all the specimens presenting the same shape and size. A dark line visible on the surface of the smaller valve indicates that it belongs to the genus *Waldheimia*.

Waldheimia resupinata, W. florella, W. Moorei, W. Bakeriæ, W. carinata, W. Meriani, W. impressa, and several other closely allied and similar-shaped species or varieties, with concave or semi-concave dorsal, and keeled ventral valves, form a group of shells all more or less intimately related, yet to some extent specifically separable. Indeed, the distinctions between some of them are so small and questionable that they may possibly be only varieties; but, as some uncertainty seems to prevail about the matter, it will be best, provisionally at least, to allow them to retain the names they have received from different palæontologists, especially as several of them characterise distinct geological horizons. This group is also closely allied to the Neocomian carinated species.

161. Waldheimia resupinata, *Sow.* Dav., Ool. Mon., p. 31, Pl. IV, figs. 1—5.

I have nothing to add to the description I gave of this species at p. 31 of my Oolitic Monograph, beyond defining its stratigraphical position.

W. resupinata occurs in the zones of *Am. margaritatus*, and *Am. spinatus* (top of Middle Lias) at Churchdown, Gloucestershire (F. Smith), at South Petherton, and elsewhere. In England it is generally met with presenting an elongated groove along the middle of its dorsal valve, but in some specimens described and figured by Mr. E. Deslongchamps it is as wide as long, and has a mesial depression of moderate depth and angularity, and in this condition it is difficult to be distinguished from some broad varieties of *Wald. carinata*, var. *alveata*, from the Inferior Oolite, as may be seen in some of the figures of *W. resupinata* in pl. 24 of M. Deslongchamps' 'Brachiopodes

Jurassiques.' It has also been found in the Middle Lias of the Island of Raasay in Scotland.

162. Waldheimia florella, *d'Orb.* Dav., Sup., Pl. XXIII, figs. 11—13.

Terebratula florella, *d'Orb.* Prodrome, No. 272 (Étage Toarcien), 1847.
— (Wald.) — *E. Deslongchamps.* Brachiopodes Jurassiques, p. 115, pl. xxvi, figs. 6, 7, 1863.
Waldheimia resupinata, 2 varr. *R. Tate.* The Yorkshire Lias, p. 419, pl. xv, figs. 12, 13, 1876.

Shell very elongated, oval; sides rounded, tapering towards the beak and front almost to a point. Dorsal valve of small depth and convexity, concave or divided by a longitudinal mesial groove of moderate depth, to which the lateral portions slope inwards, being slightly and abruptly elevated close to the margin in the posterior half of the valve. Ventral valve very deep, and keeled or roof-shaped; sides almost flat, beak but slightly produced, incurved, and truncated by a small foramen completed anteriorly by narrow deltidial plates; beak ridges very sharply defined; surface smooth, marked by concentric lines of growth.

Length 12, width 8, depth 6 lines.

Obs.—M. E. Deslongchamps, who has seen specimens of this shell, at once referred it to *W. florella*, d'Orb., and considers it to be specifically distinct from *W. resupinata*. Mr. R. Tate, at p. 419 of his 'Yorkshire Lias,' proposes two varieties for this shell.

Var. *a*, Sup., Pl. XXIII, fig. 11, "is (he states) the commonest shell in the Cleveland Main Seam, to which it is confined. This form differs from the type in being more elongated and narrower; the medial sulcus is deeper, and the sides consequently more elevated; it shows a great approach to *W. carinata* of the Inferior Oolite."

Var. *b* (pyriformis), Dav., Sup., Pl. XXIII, fig. 12, 13, "has occurred to me only in the shelly shale (or 'cockle-bed') below the Main Seam at Eston. This variety exhibits a much greater departure from the usual examples of this species in its ovate shape, gibbous valves, and the shallow or ill-defined sulcus on the brachial valve, but agrees with the large specimens of the species figured by Davidson."

W. florella occurs in the zone of *Am. spinatus*, Middle Lias, at Wilton (Phillips), Eston, Upleatham, Hobbs Hill, Skenningrove, Belman, Yorkshire (Tate); Churchdown Hill, Gloucestershire (Walker). Mr. Deslongchamps states in his description of this species that it occurs in France in the lower beds of the Middle Lias with *W. numismalis* and a small species of *Gryphæa cymbula*. It is also found at Vieux Pont in Normandy, and has been collected both in Germany and Spain.

163. Waldheimia Moorei, *Dav.* Ool. Mon., p. 33, Pl. IV, figs. 6, 7.

This fossil is stated by Mr. E. Deslongchamps to be a well-marked variety of *W. resupinata*, and is found in the same bed and localities. It seems to me, however, to differ more from *W. resupinata* than does this last from *W. florella*. Dr. Oppel mentions the localities of Pliensbach, near Boll, and Hinterweiller, near Tübingen ('Die Jura-Formation,' p. 184).

164. Waldheimia Bakeriæ, *Dav.* Ool. Mon., p. 38, Pl. V, fig. 11.

Dr. Oppel, in his 'Die Jura-Formation,' p. 184, refers this species (?) to *W. Heyseana* of Dunker, but I do not yet see any reason for that conclusion. Dr. D. Brauns informs me by letter that much confusion exists respecting it, as Quenstedt mingled the true *W. Heyseana* with young specimens of *W. Waterhousi*, but he corrected his mistake subsequently in the 'Die Brachiopoden,' where he gives accurate figures of the beak, deltidium, and foramen of the true *W. Heyseana*. According to Dr. Oppel and Mr. J. F. Walker, who have visited the locality of Bugbrook, near Weedon, in Northamptonshire, the specimen in the British Museum was not, as the label indicates, derived from the Inferior Oolite, as was supposed to be the case, but from the Middle Lias, that formation occurring in the locality. The Lincolnshire Limestone and the red Northamptonshire iron-sands represent the Inferior Oolite in this district. Mr. E. Deslongchamps is, moreover, now of opinion that the shell he described in his 'Brachiopodes Jurassiques' under the name *T. Heyseana* belongs to another species.

165. Waldheimia carinata, *Lam.* Dav., Ool. Mon., p. 35, Pl. IV, figs. 11—14 (not 15, 16, 17); Sup., Pl. XXIII, figs. 14, 15.

Waldheimia carinata, *Dav.* Proc. of the Dorset Nat. Hist. and Antiquarian Field Club, pl. iii, figs. 6, 7, 1877.

Mr. E. Deslongchamps observes that, although *W. carinata* is a well-characterised species, it might be confounded with several Liassic and Oolitic shells. I might add that it even resembles some Neocomian forms. The shape, however, of the exceedingly small foramen in *W. resupinata*, the Liassic species, as compared with the larger and oval foramen of the Oolitic species, would alone suffice to distinguish the two, even if we left out of account the other remarkable characters belonging to *W. resupinata*, such as its very

carinated dorsal valve, much incurved beak, and very sharply defined beak-ridges. *W. florella* is a more elongated form, with a much less convex dorsal valve than *W. carinata*. Nevertheless, as observed by Mr. E. Deslongchamps, in comparing them one with another we cannot avoid tracing a kind of connection in a series of forms, but slightly modified, succeeding each other as we rise in the series of Jurassic deposits. I entirely concur in the view expressed by my distinguished friend, and especially in his conclusion that the study of the Brachiopoda confirms us more and more in our belief as to the unlimited variability of the species, that we cannot admit that each period sees the first appearance of the species it contains or their sudden disappearance just at the precise moment when so many others make their first appearance. I might likewise add that, in many cases, the prevalent desire of limiting the practical range of species to their supposed limited horizons, overlooking their essential characters and variability, has led to the raising to the rank of distinct species mere variations or slight modifications in shape of no real specific value. This fact is amply verified by the study of the *W. resupinata* group, and is even more remarkable in that multitude of perplexing and so-termed distinct species (?) that have been proposed for the *T. biplicata* group. Mr. J. F. Walker considers, however, that it is advisable to give a name to a well-marked variety when it is constantly found in a given geological horizon, although it may be connected by rare forms with other species ; and also for the purpose of limiting the extent of variation of a form bearing the same name, so that there can be no doubt which variety is referred to when it is stated to occur in a certain district.

W. carinata is not very uncommon at Bradford Abbas and Broadwinsor in Dorset and Somersetshire. Some specimens are somewhat truncated at the front margin (Dav., Ool. Mon., Pl. 4, fig. 14).

Two varieties of *W. carinata* may be recorded :—

166. *Var.* Mandelslohi, *Oppel.* Dav., Sup., Pl. XXIII, figs. 16—18.

Terebratula Mandelslohi, *Oppel.* Die Jura-Form., p. 495, 1857.
— carinata-alveata, *Quenstedt.* Petrefactenkunde Deutschlands Brachiopoden, p. 349, pl. xlvii, figs. 47—50, 1871.
— (Waldheimia) Mandelslohi, *E. Deslongchamps.* Brach. Jur., p. 295, pl. lxxxv, figs. 3—5, 1874.
Waldheimia — *Dav.* Proc. of the Dorset Nat. Hist. and Antiq. Field Club, pl. iii, fig. 8, 1877.

This variety, as observed by Mr. E. Deslongchamps, approaches very nearly in shape to *W. carinata*, of Lamarck, and, indeed it appears to me to be nothing more than a wide variation in shape of the Lamarckian species. If one gives a glance at Deslongchamps' figure of a wide form of *W. carinata*, ' Brach. Jur.,' Pl. 62, figs. 7 and 10, and then

at his figures *W. Mandelslohi*, p. 85, figs. 4 and 5, I think any one would feel puzzled to define in what particular they differ. The var. *Mandelslohi* is, however, broader and shorter, the margin of the shell is sharper than in the true typical *W. carinata*. In this condition it occurs in the Lower Trigonia-grit (Inferior Oolite) at Cleeve, Crickley, and Leckhampton Hills, near Cheltenham, also at Bradford Abbas, in Dorsetshire.

It differs from *Wald. Meriani* by the sharpness of the edges of its valves, which come together at a very acute angle. The shell appears also to be thinner. It likewise agrees closely with specimens from the "Braun Jura" of Streichen and Gomelshausen, in Germany. Professor Quenstedt was quite correct in considering it only a variety of *W. carinata*, adding as a distinction the word *alveata*.

A small variety, perhaps, of the same shell as above described (Dav., Sup. Pl. XXIII, figs. 21, 22,) occurs with it at Bradford Abbas. It may be its young state.

167. Var. *Blakei*, Walker, MS. Dav., Sup. Pl. XXIII, figs. 19, 20.

In this variety the mesial depression in the dorsal valve is small, and the form of the shell more circular, or ovate, but there appears to exist every passage between it and the var. *Mandelslohi*, and between this last and true *W. carinata*.

This variety is briefly described, but without name, by Messrs. W. A. Hudleston and F. Walker in their printed communications to the Monthly Meetings of the Yorkshire Philosophical Society, 1877. They mention that the smaller valve is carinated, somewhat resembling *Wald. Walkeri*, Dav., from the Neocomian of Tealby.

Specimens of this variety were found by Mr. Hudleston in blocks of Shelly Dogger, belonging to the yellow sand (Inf. Ool.), which had fallen from the cliffs on the Yorkshire Coast; but others usually occur below the *Terebratula*-bed. It does not appear to have much exceeded 9 lines in length, by 7 in breadth and 4 in depth. It is named after the Rev. J. F. Blake, who has done good work among the Secondary rocks of England.

168. Waldheimia Meriani, *Oppel.* Dav., Ool. Mon., p. 33, Pl. IV, fig. 8, and Pl. X, fig. 7.

Terebratula impressa (pars), *Dav.* Ool. Mon., p. 33, pl. iv, fig. 8, and pl. x, fig. 7 (not other figures), 1851.
— Meriani, *Oppel.* Die Jura-Formation, p. 424, 1857.
— — *E. Desl.* Brach. Jur., p. 238, pl. lxiv, figs. 1—5, 1872.
Waldheimia — *Dav.* Proceedings of the Dorset Nat. Hist. and Antiquarian Field Club, pl. iii, fig. 9, 1877.

In 1851 I considered the Inferior-Oolite shell under description and the Oxford-Clay *W. impressa* to be varieties of a same species. Many specimens of the two appeared to be undistinguishable. Dr. Oppel and Mr. E. Deslongchamps believe them to be distinct; and, as they are found in different horizons, they had, perhaps, better be considered, at least provisionally, as such. Mr. Deslongchamps states that "the very great and regular curvature or convexity of its larger valve, and its smaller size distinguish it from *W. carinata*, with which it is found associated, and which it resembles in the concavity of its smaller valve."

W. Meriani is broadly suboval, and either as wide as long, or a little longer than wide; broadest posteriorly, tapering anteriorly, and slightly indented in front. Ventral valve deep and keeled; beak much incurved, and truncated by a small circular foramen lying close to the umbone of the smaller valve; beak-ridges sharply defined. Dorsal valve slightly convex, especially posteriorly, and divided into two portions by a deepish median groove to which the lateral portions of the valve slope on either side. Interior not known; but, no doubt, the loop was long as in Waldheimia. Surface smooth, and marked only by concentric lines of growth.

Length of a rather large specimen 12, width 10, depth 8 lines.

Obs.—I cannot quite agree with Mr. E. Deslongchamps' statement that *W. impressa* is more elongated than *W. Meriani*. It is so only occasionally. *W. Meriani* occurs in the Inferior Oolite, or zone of *Am. Humphresiana*. It is common at Ravensgate Hill, near Cheltenham, rare near Sherborne, and at Bradford Abbas, &c. In France it is not abundant in Normandy, but is common at Niort and Saint Maixent (Deux-Sevres), near Avallon (Yonne), and Macon (Soâne-et Loire) according to Deslongchamps. Also at Thurnan, Bopfingen, Gommelshausen, &c., Swabia. This species is allied to the Neocomian species *W. hippopus*, Römer.

169. Waldheimia impressa, *Von Buch*. Dav., Ool. Mon., p. 33, Pl. IV, figs. 9 and 10 (not 8); Sup., Pl. XXIV, fig. 32.

Mr. J. F. Walker informs me by letter that he and Mr. A. Wanklyn have microscopically examined the shell-structure of *W. impressa* and *W. Meriani*, and that they found that the canals traversing the shell in *W. impressa*, from the Oxford Clay, were comparatively larger and closer than in *W. Meriani* from the Inferior Oolite of Cheltenham.

Mr. Deslongchamps states at p. 239 of his 'Brachiopodes Jurassiques' that *W. impressa* occurs, in France, in the beds characterised by *Am. Lamberti* (Oxford Clay). Some fine examples from St. Clements, Oxford, are preserved in the Oxford Museum. *W. impressa* is found in the Oxford Clay at St. Ives near Huntingdon, and

at Eye near Peterborough. There is a specimen in the York Museum from the Oxford Clay of Scarborough Castle Hill; it was part of the Bean Collection: it has a MS. name *Terebratula lævigata*, Bean.

170. Waldheimia Leckenbyi, *Walker*, MS. Dav., Ool. Mon., Appendix to Vol. I, Pl. A, fig. 19; Sup., Pl. XXIII, figs. 1—4.

Terebratula pentahedra, *S. Woodward* (not of Münster). Gray's "Cat. of Mollusca in British Museum, Brachiopoda," p. 73, 1853.

— submaxillata ?, *Dav.* (not of Morris). Ool. Mon. Appendix, vol. i, pl. A, fig. 19, 1855.

Shell subpentagonal, longer than wide, broadest posteriorly; sides converging, and almost straight anteriorly; front-line short, nearly straight; dorsal valve very slightly convex, almost flat, with (in adult individuals) a narrow, shallow, longitudinal depression along the middle. Ventral valve convex, much deeper than the opposite one, longitudinally keeled along the middle; beak moderately incurved, and truncated by a rather small circular foramen completed by two small deltidial plates; beak-ridges sharply defined. Surface smooth, marked at intervals by concentric lines of growth. Loop long. Proportions variable. A large example measured—

Length 18, breadth 16, depth 9 lines.

Obs.—This well-marked species had been referred by mistake to *T. pentahedra*, Münster. *T. pentahedra* is, however, a small species occurring in the Coral Rag of Saxony and Bavaria, and differing materially from the species under description. It occurs abundantly in the Inferior Oolite of Leckhampton Hill, near Cheltenham, also in the same formation at Stroud. This species has been named by Mr. J. F. Walker after his friend the late Mr. Leckenby, of Scarborough.

171. Waldheimia (?) humeralis, *Römer*. Dav., Sup., Pl. XXIV, figs. 18, 19.

Terebratula humeralis, *Römer*. Petref. der N.-Deutsch. Oolith., Nachtrag, p. 21, pl. xviii, fig. 14, 1839.

— pentagonalis, *Bronn*. In Mandelsloh; Bronn's Neues Jahrbuch für Min., &c., p. 568, 1841.

— humeralis, *Thurmann* et *Etallon*. Lethæa Bruntrutana, p. 284, pl. xli, fig. 4, 1862.

— — *Rigaux*. Notice Stratigraphique sur le Bas Boulonnais, 1863.

Waldheimia — *Schloenbach*. Brachiopoden der Norddeutschen Cenoman-Bildungen, p. 37, 1867.

TEREBRATULA HUMERALIS, *Quenstedt.* Die Brach. Deutschlands, p. 335, pl. xlv, figs. 84—89, 1870.

— — *De Loriol.* Desc. Géol. et Pal. des Étages Supr. de la Haute Marne, p. 414, pl. xxv, figs. 21, 27, 1872.

— (WALDHEIMIA) *Dav.* Quarterly Journal Geol. Soc., vol. xxix, p. 197, pl. viii, fig. 4, 1873.

WALDHEIMIA — *De Loriol.* Mon. Pal. Géol. des Étages supr. Formation Jurassique Boulonnais, p. 238, 1875.

Shell subpentagonal, with valves moderately convex, longer than wide, and tapering posteriorly, slightly pinched in laterally in its anterior half, and rounded in front. No fold or sinus in either valve; surface smooth, and marked at intervals by concentric lines of growth; beak incurved, and truncated by a small circular foramen, separated from the hinge-line by a deltidium in two pieces; beak-ridges moderately defined. Ventral valve most convex; dorsal valve moderately so, sometimes nearly flat. Interior not known. Proportions variable; an average-sized specimen measured—

Length 17, width 14, depth 9 lines.

Obs.—I am not quite certain whether this species belongs to the genus *Terebratula* or *Waldheimia*, the loop not having been hitherto described. A short and very slightly indented line, extending from the umbone to about one third of the length of the smaller valve, indicates the existence of a small septum, which leads me to suspect that it may have possessed a long loop. The species seems to have been very much misunderstood by various palæontologists, since it has been referred to *T. ventroplena* and *tetragona* by Römer, to *T. carinata* by Leymerie, partly to *T. bucculenta* by d'Orbigny, to *T. pentagonalis* and *T. pentagona* by Quenstedt, and to *T. Kimmeridgensis* and *T. Leymerei* by Deslongchamps. M. de Loriol, in his excellent work on the 'Upper Jurassic Rocks and Fossils of the Haute Marne and of the Boulonnais,' gives complete synonyms and description of this species. It was first recognised as a British fossil by myself, having been found in the Upper Oolites of Garty, in Sutherlandshire. In France, according to M. de Loriol, it occurs in the "Calcaire à Astartés" or upper portion of the Coralline Oolite, a zone underlying the Kimmeridge.[1] It is quoted by M. de Loriol from Harméville, Champcourt, &c. It abounds, according to the same authority, in the Boulonnais, and particularly in the upper beds of the Étage Séquanien, but less commonly, and of smaller size, in the Étage Ptérocien. He adds that he has found it in abundance at Baden (Argovia) in the zone of *Am. tenuilobatus*, and that Mr. Struchmann has recently discovered it at Ahten, in the upper beds of the Terrain Séquanien, associated with *Ostrea virgula*.

[1] Dr. Oppel ('Die Jura') records it from the zone of *Pteroceras oceana* at Lindener and Tönnes Berg, near Hanover.

172. Waldheimia, sp. (?) Sup., Pl. XXIV, fig. 20.

In the Lower Calcareous Grit or zone of *Am. perarmatus* of Bramberry Hill, Sutherlandshire, internal casts of an undetermined species of *Waldheimia* have been collected by Prof. Judd, but not sufficiently complete (the shell being absent) to warrant a specific identification. These oval internal casts are very remarkable on account of the very great length of the longitudinal fissure in the dorsal valve, indicating the presence in the smaller valve of an unusually long and large septum. In shape these casts most approach *W. humeralis*, but the length of the septum is very different from that observable in the last-named species.

173. Waldheimia cardium, *Lamarck*. Dav., Ool. Mon., p. 43, Pl. XII, figs. 13—18; Sup., Pl. XXIV, figs. 21, 22.

I have very little to add to the description I gave of this species at p. 43 of my Oolitic Monograph. I may, however, observe that in the opinion of Mr. C. Moore the small *T. furcata* of Sow. is not a young age of *W. cardium*, but a well-defined small species of *Terebratula*, its loop being doubly attached, as will be seen in the illustration we give in Pl. XIV, fig. 16 of this Supplement.

This shell occurs in the Great Oolite and Bradford Clay of Bradford, and Tetbury Road Station. The Rev. F. Smithe informs me that he has found it in the Forest Marble of Malmesbury. Mr. J. F. Walker assures me also that a variety he distinguishes by the name of *Leckhamptonensis* occurs (but very rarely) in the Inferior Oolite or Pea Grit at Leckhampton Hill, near Cheltenham, and in the same formation at Bradford Abbas in Dorsetshire (Sup., Pl. XXIV, fig. 21). In the last-named locality, however, it must be exceedingly rare, for out of upwards of 1000 specimens from the district lent me by Professor Buckman and Mr. Darell Stevens, I did not find a single example referable to the species or variety above named. There is in the Museum of the Geological Survey, Jermyn Street, a specimen from the Inferior Oolite of Andoversford. This variety is more elongated and ovate than the specimens from the Great Oolite and Bradford Clay, the beak is less incurved, and the beak-ridges are sharper. Fine examples may be obtained from the Forest-marble at Islip in Oxfordshire.

ADDITIONAL OBSERVATIONS IN CONNECTION WITH THE SPECIES PREVIOUSLY DESCRIBED IN THIS SUPPLEMENT.

WALDHEIMIA (Terebratula) ANGLICA, *Oppel.* Sup., p. 135, Pl. XXIII, figs. 23—26.

This species should, according to Mr. J. F. Walker, be placed in the genus *Waldheimia.* Subsequent to my description of the species in p. 135 of the Monograph, I received from Mr. J. F. Walker two specimens found by Mr. L. Kennedy in the equivalent of the Trigonia Grit (Inferior Oolite), near Bradford Abbas, in Dorsetshire. Mr. Darell Stevens also obtained a great number of well-characterised specimens from the same formation at Crewkerne Station, a locality about seven miles from Bradford Abbas. This small species is much less convex than *T. sphæroidalis*, the valves are often very slightly convex, but much thickened near the margin. The shell does not appear to have generally much exceeded 9 lines in length by 8 in breadth and 5 in depth. Some of the specimens show a dark line on the smaller valve, indicating that the loop was long. This species seems related to *Wald. Lycetti* of the Upper Lias.

WALDHEIMIA (Terebratula) HUDLESTONI, *Walker.* Sup., p. 135, Pl. XVII, figs. 14—16.

WALDHEIMIA HUDLESTONI, *Walker.* On the Distribution of the Brach. in the Ool. Strata of Yorkshire, Monthly Communications of Yorkshire Phil. Soc., 1877.[1]

[1] In connection with the Yorkshire species Messrs. Hudleston and Walker append the following table to their valuable communication:

OOLITIC BRACHIOPODA FOUND IN YORKSHIRE.	Blue Wyke Sands and Dogger, Passage-beds and Base of Inferior Oolite.	Millepore series and its inland equivalents, the Whitwell and Crambeck Limestones.	Scarborough Limestone.	Cornbrash and *Aviculæ*-shales.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit, and Passage-beds.	Coralline Oolite.	Coral Rag.	Supra-coralline Beds.	Kimmeridge Clay.
Lingula Beanii, *Phil.*	*										
Lingula ovalis, *Sow.*	...	...	...	...	...	...	...	...	...	...	*
Discina reflexa, *Sow.*	*										
Discina latissima, *Sow.*	...	...	...	...	...	...	...	...	...	...	*
Terebratula Bentleyi, *Dav.*	...	...	...	*							
Terebratula bullata, *Sow.*	...	*									

At p. 133 of this Supplement this species was placed with uncertainty in the genus *Terebratula;* since then Mr. J. F. Walker has discovered that it has a long loop, and consequently belongs to the genus *Waldheimia.* It occurs abundantly in the passage-beds of the Lower Calcareous Grit at Filey Brigg on the Yorkshire coast, also at Hackness, near Scarborough, in an intercoralline brash of a Lower Coral Rag, at about the same geological horizon.

WALDHEIMIA (Terebratula) BULLATA, *Sow.* Dav., Sup., p. 138, Pl. XXI, figs. 21, 22.

Since this species was described several well-preserved specimens have been obtained by Mr. J. F. Walker from the Fuller's Earth of Whatley, near Frome. These specimens show the dark line on the smaller valve, indicating the presence of a septum, therefore, this species belongs to the genus *Waldheimia.* It occurs rather plentifully, associated

OOLITIC BRACHIOPODA FOUND IN YORKSHIRE.	Blue Wyke Sands and Dogger, Passage-beds and Base of Inferior Oolite.	Millepore series and its inland equivalents, the Whitwell and Crambeck limestones.	Scarborough Limestone.	Cornbrash and *Avicula*-shales.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit, and Passage-beds.	Coralline Oolite.	Coral rag.	Supra-coralline Beds.	Kimmeridge Clay.
Terebratula Fileyensis, *Walk.* ...	...	...	...	...	...	...	*				
Terebratula insignis, var. Maltonensis, *Oppel.*	...	...	...	...	...	....	...	...	*		
Terebratula intermedia, *Sow.* ...	...	...	...	*							
Terebratula submaxillata, *Dav.* ...	*	*	*								
Terebratula trilineata, *Y. and B.* ...	*										
Waldheimia Blakei, *Walk.*	*										
Waldheimia bucculenta, *Sow.* ...	...	...	...	...	...	...	*				
Waldheimia Hudlestoni, *Walk.* ...	...	...	...	...	...	...	*				
Waldheimia impressa, *v. Buch.* ...	...	...	...	...	...	*					
Waldheimia lagenalis, *Schlot.* ...	...	...	...	*							
[1]Waldheimia obovata, *Sow.*	...	...	...	*							
Waldheimia ornithocephala, var. umbonella, *Lam.*	...	...	...	...	*						
Rhynchonella Crossii, *Walk.* ...	...	*									
Rhynchonella cynocephala, *Rich.* ...	*										
Rhynchonella inconstans, *Sow.* ...	...	...	...	...	...	...	...	...	...	...	*
Rhynchonella lacunosa, *Schlot.* ...	...	...	...	...	...	...	*				
Rhynchonella Leedsii, *Walk.* ...	...	...	...	*							
Rhynchonella socialis, *Phil.*	...	...	...	...	*	*					
Rhynchonella spinosa, *Sow., var.* ...	...	*									
Rhynchonella subobsoleta, *Dav.* ...	*										
Rhynchonella Thurmanni, *Voltz.* ...	...	...	...	...	...	...	*				

[1] Three varieties of *Waldheimia obovata* occur, viz., typical, narrow, and rhomboidal. Since this list was published *T. ballata* has been found to be a *Waldheimia,* and *W. Margarita,* Oppel, has been found in the Coral-rag of Yorkshire.

with *Ter. globata*, Sow., *Ter. reticulata*, Sow., and *Rh. varians*, var. *Smithii*, in the road-side cutting in the village; the best specimens are obtained out of the thin beds of clay which alternate with the bands of light yellow stone. It also occurs, but sparingly, nearer to Frome along with *Wald. ornithocephala*, Sow., and *Rh. varians*, var. *Smithii*, and *T. globata*, Sow. The species also occurs in the blue sandy limestone a little above the Whitwell Inferior Oolite at Crambeck, near Castle Howard, Yorkshire, where it is rare to find good specimens, but crushed examples are common.

I may add that I found some specimens among the vast numbers collected, and kindly forwarded to me by Mr. J. F. Walker and other friends, which may, perhaps, hereafter be considered as representing species not described in this Monograph. As, however, these occurred only in single, and often imperfect examples, I have deemed it preferable to omit them in this Supplement. I should likewise wish to refer the reader to Prof. Edward Hull's very instructive memoir on the 'Geology of the Country round Cheltenham,' accompanying and explaining Sheet 44 of the Geological Survey Maps (1857), in which all the formations from the Keuper, or New Red Sandstone, up to the Pleistocene Deposits are described. Lists of the fossils, including Brachiopoda, are enumerated from each formation where they occur, the localities being carefully appended. A paper on the "Fossil-beds of Bradford Abbas and its Vicinity," by Professor Buckman, in the 'Proceedings of the Dorset Natural History and Antiquarian Field Club' for 1877, may also be advantageously consulted.

Genus RHYNCHONELLA, *Fischer.*

174. RHYNCHONELLA WRIGHTII, *Dav.* Ool. Mon., p. 69, Pl. XIV, fig. 1; Appendix to vol. i, p. 21, Pl. A, fig. 27.

Nothing new. Pea-grit (Inferior Oolite), Cheltenham district.[1] This shell appears

[1] The Inferior Oolite of the Cheltenham district has been divided in the ascending order as follows:—1. The *Pea Grit*, which reposes directly on the passage-beds, or Ammonite-sands (Upper Lias of Wright), forms the base of the Inferior Oolite, and is composed of multitudes of flattened spheroidal masses about the size of a pea, one fourth or one fifth of an inch in diameter; it varies from thirty-eight to forty in thickness in the district. It contains many Brachiopoda, which will be found enumerated in the sequel. 2. *Oolitic Freestone.*—This constitutes the middle division of the Inferior Oolite, and contains many fossils peculiar to itself. 3. *Oolite Marl.*—This forms a well-defined zone, and consist of layers of white and yellowish marl and marly stone, though, according to Prof. Hull, sometimes almost entirely in a consolidated state, as at Leckhampton quarries. It also contains many species of Brachiopoda, and is generally non-oolitic, and in the face of a cliff may easily be distinguished by its chalky aspect. 4. *Freestone*, consisting of a regularly stratified Oolite, compact, and not so fossiliferous as the remaining beds of the series. Very few species of Brachiopoda have been met with in this division. 5. *Ragstone.*—This is always, according to Hull, the highest member of the Inferior Oolite, and presents a remarkable

still to be a very rare fossil in Great Britain, but it occurs rather abundantly in the Inferior Oolite of Condé-sur-Sarthe, near Alençon, in France.

175. Rhynchonella furcillata, *Theodori*. Dav., Ool. Mon., p. 69, Pl. XIV, figs. 2—5; Sup., Pl. XXVII, figs. 1—3.

Nothing new. This species occurs throughout the Middle and Upper Lias. It was found by Mr. R. Tate in the *Am. armatus* beds of Hallaig, Raasay, in Scotland, also in the Zone of *Am. Jamesoni* at Huntcliff, and in the *A. armatus* beds at Kirby Underdale, in Yorkshire. Some very remarkable transverse specimens from the Middle Lias or Marlstone, near Shipton Grove, may be seen in the Museum of the School of Mines, London.

176. Rhynchonella rimosa, *Von Buch*. Dav., Ool. Mon., p. 70, Pl. XIV, figs. 6, 6 *a*; Sup., Pl. XXVII, fig. 10.

Nothing new. *Rh. rimosa* occurs in the Zones of *Am. Jamesoni*, *A. capricornus*, and *A. margaritatus* (Middle Lias). Mr. R. Tate quotes it from the Zone of *Am. Jamesoni* at Huntcliff and Coatham Scars, in Yorkshire. It is especially abundant in the *Am. Ibex* Zone at Churchdown Hill, Gloucestershire (F. Smithe). It has also been found at Tobermory in the Island of Mull, Scotland. Up to a certain age the ribs are all simple, and the fold scarcely raised above the general convexity of the valve, but with age these ribs combine by twos or threes near the margin, forming larger ribs in adult individuals. *Rh. rimosa* rarely exceeds 9 lines in length, by something less in breadth. Professor Brauns considers *Rh. rimosa curviceps*, Quenstedt, and *T. sub-serrata*, Münster, to be synonyms of *Rh. rimosa*.

177. Rhynchonella serrata, *Sow*. Dav., Ool. Mon., p. 85, Pl. XVI, figs. 1, 2.

This fine and very distinct species occurs in the upper portion of the Middle Lias or Zones of *Am. margaritatus* and *Am. spinatus*. It has been obtained by Mr. J. F. Walker from Sowerby's original locality Chideock, near Charmouth, Lyme Regis.

contrast to the beds already described; for, although only thirty-eight feet thick at Leckhampton Hill, or one sixth of the whole formation, yet it preserves a very uniform thickness over nearly the whole district, and at its south-east extremity is the sole representative of the Inferior Oolite, and contains many species of Brachiopoda. Towards the south-eastern part of the district the Ragstone gives place to a coarse rubbly white Oolite called *Clypeus-grit*. Over this deposit comes the Fuller's Earth, separating the Great from the Inferior Oolite, and containing a general assemblage of forms common to both.

178. Rhynchonella plicatella, *Sow.* Dav., Ool. Mon., p. 86, Pl. XVI, figs. 7, 8; and Sup., Pl. XXVII, figs. 4—7.

Nothing new. Inferior Oolite. Is abundant at Bradford Abbas, Crewkerne Station, near Sherborne, and other places in Dorsetshire and Somersetshire. The young of this species are of an elongated triangular shape and much flattened.[1]

179. Rhynchonella Sutherlandi, *Dav.* Sup., Pl. XXV, figs. 5—8.

Rhynchonella Sutherlandi, *Dav.* Quart. Journ. Geol. Soc., vol. xxix, p. 196, pl. viii, figs. 1, 2, 1873.

Shell transversely oval, wider than long, greatest breadth about the middle. Ventral valve convex; sinus wide, moderately deep; foramen rather small, placed under the incurved extremity of the beak, and surrounded and slightly separated from the hinge-line by a deltidium of small dimensions. Dorsal valve deeper and more convex than the opposite one, sometimes very gibbous, and divided into three portions, the central one being formed by a wide mesial fold. Surface of each valve marked with from sixteen to thirty large angular ribs, of which from six to twelve occupy the fold, five to thirteen the sinus. Proportions very variable. A large specimen measured—

Length $2\frac{2}{8}$ inches, breadth $2\frac{6}{8}$ inches.

Obs.—This is one of the largest species of the genus with which I am acquainted, having been exceeded in size, as far as I am aware, only by *Rh. multicarinata*, Lamarck, *T. peregrina*, Von Buch, and the *Rh. inconstans speciosa* of Münster. In general shape and character *Rh. Sutherlandi* most nearly approaches the smaller *Rh. Renauxiana*,

[1] The student is referred for further details respecting the species of Brachiopoda from the Inferior Oolite of the Bradford Abbas district to my paper published in the 'Proceedings of the Dorset Natural History and Antiquarian Field Club' for 1877. Therein the following species are figured and described:—1. *Ter. perovalis*, Sow., and var. *ampla*, Buckman. 2. *Ter. Stephani*, Dav. 3. *Ter. Phillipsii*, Morris. 4. *T. Ferryi*, E. Desl. 5. *T. globata*, Sow. 6. *T. Eudesei*, Oppel. 7. *T. sphæroidalis*, Sow. 8. *T. decipiens*, E. Desl. 9. *T. Wrightii*, Dav. 10. *T. Craneæ*, Dav. 11. *T. Buckmani*, Dav. 12. *Waldheimia anglica*, Oppel. 13. *W. Waltoni*, Dav. 14. *W. emarginata*, Sow. 15. ? *W. carinata*, Lamk. 16. *W. Meriani*, Oppel. 17. *W. ornithocephala*, Sow. 18. *Wald.*, sp. 19. ? *W. cardium*, Lam. 20. *Rh. plicatella*, Sow. 21. *Rh. subtetrahedra*, Dav. 22. *Rh. subangulata*, Dav. 23. *R. Forbesei*, Dav. 24. *Rh. spinosa*, Schl. 25. *Rh. senticosa*, Von Buch. 26. *Rh. ringens*, Herault. 27. *Rh. cynocephala*, Rich. 28. *Rh. Stephansi*, Dav. 29. *Rh. parvula*, E. Desl. This is a very remarkable assemblage of Brachiopoda from a single formation and district. Prof. Buckman appends to the paper a very interesting notice of the geology of the Inferior Oolite.

d'Orb., from the Upper Neocomian rocks of the south of France. It varies likewise very much in the number and strength of its ribs; but this is a feature common to every species of the genus.

This shell appears to be a common fossil in the Upper Oolitic Grey Limestone (sub-coralline beds?) at Garty, in Sutherland.[1]

The specimens figured having been communicated by the Rev. J. M. Joass from the Dunrobin Museum, I have named the species after his Grace the Duke of Sutherland, in humble appreciation of the services he is rendering to science by the formation of a local Museum at Dunrobin, in Scotland.

180. Rhynchonella inconstans, *Sow.* Dav., Ool. Mon., p. 87, Pl. XVIII, figs. 1—4; and Sup., Pl. XXVI, figs. 1—6.

I have not much to add to the description I gave of this important species at p. 87 of my Oolitic Monograph. I have always considered that in dealing with a species, or in comparing it with others, full-grown examples should be made use of, for the animal has then acquired all its characters. Variations in shape, due to age, should be afterwards considered. This is especially necessary with *Rh. inconstans*, for when full grown it attains to fully 1 inch 8 lines in length, by 1 inch 9 lines in width, and 1 inch 3 lines in depth, being very globose and gibbous. The fold and sinus, being but slightly defined or raised above the general convexity of the shell, are shifted either to the one or other half of the shell, thus giving it a twisted or contorted and unsymmetrical appearance. The surface of both valves is also, in the full-grown form, marked with from thirty to forty simple, regular, radiating ribs or costæ, scarcely ever exceeding two lines in breadth (if as much) and one in height. I have seen many specimens agreeing with the typical form above described, from the size of less than two thirds of an inch to the dimensions of the full-grown individuals above noticed (see 'Ool. Mon.,' Pl. XVIII, figs. 1—2; and Sup, Pl. XXVI, figs. 1, 2).

We will now notice the exceptional shapes assumed by this most variable species, and the one that can be sometimes almost confounded with a closely allied form occurring in the Supra-coralline red rock of Abbotsbury. In Sup., Pl. XXVI, figs. 3—6, will be seen examples of this variety from the Kimmeridge Clay of Wooton Basset, and Shotover Hill, near Oxford. Fig. 3 shows a symmetrical shell, much resembling in size and shape some specimens of *Rh. obsoleta*. In this form the mesial fold is in the middle, a very uncommon occurrence in *Rh. inconstans*. In fig. 4, from the same locality, we have the

[1] For a full description of this important locality, as well as that of Allt-na-cuil, see Prof. Judd's admirable memoir "On the Secondary Rocks of Scotland," 'Quart. Journ. of the Geol. Soc.,' vol. xxix, p. 179 and 182, 1873.

twisted character of *Rh. inconstans*, but with not more than twenty strong ribs on each valve, and this variation so nearly approaches, by its smaller dimensions and less gibbous valves, to some of the Abbotsbury specimens as to be scarcely distinguishable. Fig. 4 is a still larger specimen, with not more than twenty-five or six strong ribs, and with an unsymmetrical frontal margin; while in fig. 6 we have a young flattened shell of the same type. None of these, however, seem to have attained the size or globose shape of the typical and adult *Rh. inconstans*.

Although *Rh. inconstans* is a common species in the Kimmeridge Clay of several British localities, it is exceedingly rare in that deposit in the Boulonnais, for Mr. E. Rigaux assured me that he never obtained more than one example, and neither Messrs. Bouchard, E. Pellat, nor myself, who have so often searched the cliffs extending on both sides of the town of Boulogne, have ever picked up a single example, nor have any traces of the species been brought to light during the Sub-Wealden boring at Netherfield, near Battle, in Sussex, though so many hundred feet of Kimmeridge Clay were traversed. One or two examples of a *Rhynchonella* were, it is true, obtained, but they were not referable to the species under description.

By some inadvertence, at p. 88, line 3, of my Oolitic Monograph, it is stated that the shell was found in the "Oxford Clay" of Wooton Basset; the word "Kimmeridge" must be substituted for that of "Oxford." Prof. Judd mentions that *Rh. inconstans* occurs in the Kimmeridge Clay of Speeton Cliffs ('Journ. Geol. Soc.,' vol. xxiv, pp. 231 and 240).

In the Supra-coralline red or rusty-coloured ferruginous rocks of Abbotsbury, near Weymouth, in Dorsetshire, we meet with a very variable species, sometimes recalling, as we have already stated, certain exceptional forms of *Rh. inconstans* (Sup., Pl. XXVI, fig. 8), *Rh. pinguis* (fig. 7), and *Rh. pectunculoides*, Et., and even *Rh. lacunosa*, Schlotheim (fig. 9). Mr. Hudleston, who sent me these three specimens for illustration, observes that, "If the three forms were taken by themselves they might very well represent three distinct species, but that they are connected together by innumerable intermediate forms, which leaves no doubt as to their belonging to a single species." He further adds, "The Abbotsbury beds are the remnants of deposits which have no absolute representatives on the coast, but which are certainly very near in position to the Coralline or Kimmeridge. In south Dorsetshire these formations pass into each other by gradations, as it were, but there is on the coast a line of demarcation above the Coral-bed, where *Rh. inconstans* appears suddenly. There is no great change in the lithology, and the Ammonites in both series appear to be the same; hence the lapse of time is not great between this muddy and disjointed Coral-band and the bed with *Rh. inconstans*."[1] The Abbotsbury shell is considered by Mr. Hudleston to be very close to *Rh. inconstans*, but it does not appear to have attained the dimensions of that species, for none of the specimens I have

[1] The reader is referred to Messrs. Blake and Hudleston's admirable memoir "On the Corallian Rocks of England," published in the xxxiii vol. of the 'Quart. Journ. of the Geol. Society of London,' p. 260, &c., 1877.

seen exceeded 1 inch 2 lines in length, by 1 inch 4 lines in breadth, and 1 inch in depth, and none of them assumed the shape and character of the full-grown *Rh. inconstans*. Therefore, when taken as a whole, the Abbotsbury fossil presents differences sufficiently marked as to lead us to consider it specifically distinct. The difficulty then arises as to its identification with some of the described species, and I have experienced the same perplexing uncertainties expressed by M. de Loriol while describing his *Rh. pinguis* (?) from the Corallian Limestone of the Mont des Boucardes in the Boulonnais. I consider it advisable to adopt Römer's name *pinguis* for the species, and to make use of Étalon's term *pectunculoides* for the variety with large ribs, that occurs at the Mont des Boucardes, near Boulogne-sur-Mer.

181. Rhynchonella pinguis, *Römer*. Sup., Pl. XXVI, fig. 7.

Terebratula pinguis, *Römer*. Petref. des Nordd. Ool. Geb., p. 41, pl. xi, fig. 15, 1836.
— corallina, *Ley*. Statistique Géologique du Dép. de l'Aube, p. 10, figs. 16, 17, 1846.
Rhynchonella pinguis, *Étalon*. Corallien du Haut-Jura, p. 155, 1859 (no figure).
— — *J. Thurman et A. Étalon*. Lethæa Bruntrutana, p. 290, pl. lxii, fig. 5, 1861.
— — *De Loriol*. Desc. Géol. et Pal. des étages sup. Jur. Haute-Marne, p. 417, pl. xxvi, figs. 4—12, 1872.

The first question to be solved is, what is Römer's *Rhynchonella pinguis*. If we refer to the figure of his species, we find that it represents a shell measuring about 9 lines in length, by 10 in breadth, and varying in depth from 3 to 7 lines, and that it is almost circular, with hardly any appreciable fold or sinus. The beak is small and incurved, with a circular foramen under its angular extremity, margined, and separated from the hinge-line by two deltidial plates. The surface of each valve is covered with from twenty to twenty-two small, almost equal-sized, radiating ribs on each valve. These are the characters of the shell figured by Römer, and they are apparently applicable also to *Rhynchonella corallina* of Leymerie: but both varied, no doubt, very much; and if we had a number of species before us, we should in all probability, obtain larger individuals, and some likewise with the fold and sinus more defined, leading us by insensible passages in form to the larger variation in shape, for which, at least provisionally, we retain the varietal designation of *pectunculoides* of Étalon.

A few small specimens found at Abbotsbury seem to agree with Römer's figure of *Rh. pinguis*, but the larger number, and perhaps all of them, partake more of the

character of Étalon's *Rh. pectunculoides*;[1] indeed, I feel uncertain whether the true *Rh. pinguis*, as figured and described by Römer, has been hitherto found in Great Britain.

182. Var. *pectunculoides*, Étalon. Sup., Pl. XXVI, fig. 8 to 12.

Rhynchonella pectunculoides,	*Étalon.*	Corallien du Haut-Jura, 1850 (name only).
—	— *Étalon.*	Lethæa Bruntrutana, p. 189, pl. xlii, fig. 3, 1861.
—	semiconstans, *Étalon.*	Lethæa Bruntrutana, p. 290, pl. xlii, fig. 4, 1861.
—	pullirostris, *Étalon.*	Lethæa Bruntrutana, p. 292, pl. xlii, fig. 12, 1861.
—	pectunculoides, *Étalon.*	Mém. d'Emul. du Doubs., 3rd ser., vol. viii, p. 372, 1864.
—	— *De Loriol.*	Mon. des étages Sup. de la Formation Jurassique du Dépt. de la Haute-Marne, p. 419, pl. xxvi, figs. 1—3, 1872.
—	pinguis, *De Loriol.*	Mon. des étages sup. de la Formation Jurassique du Boulonnais, p. 241, pl. xxv, figs. 21 to 26, 1875.

It seems to me that all M. de Loriol's figures of *Rh. pinguis*, as described in his magnificent work on the Boulonnais, should be referred to the variety *pectunculoides*, as well as the specimens from Abbotsbury, figured in our Supplement plate, with perhaps the exception of fig. 7.

This variety (or species?) varies considerably in shape, as may be seen from the specimens we have selected for illustration. None of the Abbotsbury specimens sent to me for inspection by Messrs. Hudleston and J. F. Walker exceeded 1 inch 3 lines in length, by 1 inch 4 lines in breadth, and 1 inch in depth.

[1] M. E. Rigaux writes me: "La vraie *Rh. pinguis*, comme je la comprend, ne se trouve pas au Mont des Boucardes, mais dans l'Oolite Corallienne d'Herdin l'Abbé, et dans le Coral Rag d'Hourez.

Oolite d'Herdin avec *T. bucculenta*. *T. subsella*, avec des variétés passant à la *T. insignis*, et une Terebratule plessee.

Argile sans fossiles.

Coral Rag avec *T. bucculenta*, *Rh. pinguis*, et *Rh. pectunculoides*.

Argile sans fossiles.

Calcaire du mont des Boucardes, avec *T. insignis*, *Rh. pectunculoides*, mais la veritable *Rh. pinguis* et *T. bucculenta* ne s'y trouvent pas.

Je pense que vous avez raison, et que la grosse Rhynchonella du mont des Boucardes est la *Rh. pectunculoides*, de Loriol.

Some specimens were proportionately less deep. In general shape they varied also considerably, some being almost globose and transversely oval, and others more or less pentagonal. Some were perfectly symmetrical, the mesial fold broad, distinct, well marked, and situated in the middle of the valve, while in others it is twisted to one or the other side, the shell then becoming unsymmetrical, as in *Rh. inconstans*. This character is, however, observable in many other species of the genus, not only in the Jurassic, but also in the Cretaceous (*Rh. contorta*), Tertiary, and even recent periods. I have examples of the living *Rh. nigricans* in which the fold and sinus are shifted to one or the other side of the valves. In the variety under description, the number of angular ribs in each valve varies from twenty to twenty-eight, and of this number from five to eight occupy the fold or sinus; the beak is moderately large and incurved, with a small circular foramen under its angular extremity.

It seems to me that *Rh. pectunculoides*, Ét., *Rh. semiconstans*, Ét., and *Rh. pullirostris*, É.t, are all referable to a single species, that is, if we are to judge from the figures in the 'Lethæa Bruntrutana.' Some specimens from Abbotsbury correspond with all Thurmann and Étalon's figures.

At p. 242 of his work on the Boulonnais, already referred to, M. de Loriol observes that "The *Rhynchonellæ* from the Upper Jurassic deposits belonging, to the *Rh. pinguis* group, are so difficult to distinguish correctly that several authors have referred them to a single species. Thus, M. Cotteau combines all the *Rhynchonellæ* from the Upper Jurassic deposits of the Department of the Yonne under the designation of *Rh. inconstans*. Dollfus does likewise with those of Havre, while Dr. Brauns recognises only the *Rh. pinguis* in the Upper Jurassic deposits of Hanover. That author observes that "*Rh. inconstans* (at least as it is understood by Mr. Davidson), is distinguishable by its shorter and more incurved beak and its less acuminated area; the specimen from the Coral Rag figured by Mr. Damon under the name of *Rh. obsoleta*, Sow., corresponds exactly with our individuals from Boulogne."

Mr. J. F. Walker proposed to me to distinguish the Abbotsbury form by the varietal designation of *Supra-corallina*, but I think that one of Étalon's names should be adopted in preference to a new one. M. de Loriol's figures of *Rh. pectunculoides* (Haute-Marne, Pl. XXVI, figs. 1—3) correspond exactly with many of the specimens from Abbotsbury. By far the larger number of the specimens from the last-named locality occur in the shape of internal casts, but examples with the shell preserved are occasionally obtained.

183. Rhynchonella lacunosa, *Schloth.* Suppl., Pl. XXVI, figs. 13, 14.

Terebratulites lacunosa,		*Schlotheim.*	Beiträge für Nat. Vers. in Leonhard's Min. Tasch., vol. vii, pl. i, fig. 2, 1813.
Terebratula	—	*Von Buch.*	Ueber Ter., p. 49, 1834, and Mém. Soc. Géol. de France, 1st ser., vol. iii, p. 150, pl. xv, fig. 22, 1838.
—	—	*Bronn.*	Index Pal., p. 1239, 1848.
—	—	*Quenstedt.*	Die Jura, p. 632, pl. lxxviii, figs. 15, 16, 1858.
—	—	*Quenstedt.*	Die Brachiopoden, p. 121, pl. xxxix, figs. 77—107, 1871.

As stated under *Rh. tetraëdra* (of this Supplement), my identification of this species at p. 96 of the Monograph on 'Fossil Brachiopoda' was incorrect, and requires to be erased, for the shell there described subsequently proved to be a variety in form of *Rh. tetraëdra*, from the Lias of Dunrobin, in Scotland.

I am acquainted with two examples only of *Rh. lacunosa* from the Jurassic Rocks of Great Britain; one from the Lower Calcareous Grit of Beedall, Wykham, in the Museum of the School of Mines (Sup., Pl. XXVI, fig. 13); and another, from the same formation at Oliver's Mount in Yorkshire (same plate, fig. 14), was communicated to me by Mr. Hudleston. Some internal casts found by Mr. Judd in the Upper Oolites of Alt-na-cuil in Sutherland may also probably be referable to Schlotheim's species; and a good series of specimens may be seen in the Dunrobin Museum.

The material at our command is not quite satisfactory; for, although those British specimens are in all probability referable to *Rh. lacunosa*, they do not exhibit the characteristic shapes of the shell. It is, I am ready to admit, a most variable shell, and, indeed, group of shells, for Quenstedt has divided it into many named varieties, such as, var. *decorata*, var. *diffissa*, var. *multiplicata*, var. *polita*, var. *rariplicata*, var. *rupicaleis* var. *silicea*, var. *sparsicosta*; and to one of these our British examples may be referred.

In external shape *Rh. lacunosa* is more or less sub-pentagonal, slightly wider than long; dorsal valve more or less convex, and usually divided into three lobes, of which the central one is more or less elevated, forming generally a slightly flattened mesial fold; beak moderately produced, and incurved, with a circular foramen under its angular extremity, margined and slightly separated from the hinge-line by small deltidial plates. Ventral valve convex, with a wide sinus of moderate depth. Surface of each valve covered with a variable number of angular ribs, of which a few sometimes bifurcate near the margin. The largest known British example measures—length 11, width 12, depth 8 lines, but the full-grown shell acquired larger proportions.

This species has a considerable geographical range. It was found abundantly by the

Rev. E. R. Lewis on the eastern slope of Mount Hermon (Lebanon), Syria. Dr. Fraas, who identified the specimens, states them to be Oxfordian.[1]

In some of the specimens I have seen from that locality the valves were extremely convex, while in others they were very moderately so.

184. Rhynchonella Boueti, *Dav.* Sup., Pl. XXVI, figs. 15, 16.

Rhynchonella Boueti, *Dav.* Annals and Mag. of Nat. Hist., vol. ix, 2nd ser., pl. xiii, figs. 4, 5, 1852.

Shell somewhat triangular or sub-pentagonal, wider than long. Valves moderately deep, the dorsal most convex, and divided into three lobes, of which the central one forms an elevated and well-defined mesial fold, somewhat laterally contracted, with a deep corresponding sinus in the ventral valve; beak acute, not much produced, with a small circular foramen under its angular incurved extremity, margined, and slightly separated from the hinge-line by narrow deltidial plates; beak-ridges well defined, leaving a slightly concave false area between them and the hinge-line. Surface ornamented by a variable number of angular ribs, about thirty in each valve, of which from four to seven occupy the fold and sinus.

Length 1 inch, width 1 inch 2 lines, depth 7 lines.

Obs.—This species was first found by myself in the upper portion of the Great Oolite at Ranville, near Caen, where it is common. It occurs in the same locality with *Rh. obsoleta*, from which, however, it is easily distinguished, more particularly by its much more elevated and pinched-in mesial fold. It is also comparatively more transverse and trilobed.

It occurs in great abundance in the Bradford Clay, in company with *Wald. digona*, a small variety of *Ter. intermedia* and *Ter. coarctata*, at Burton Bradstock, near and north-east of Bridport in Dorset, where it was discovered by Mr. Darell Stephens. It was also found by Mr. J. F. Walker to be a common fossil in the Cornbrash at Laington, near Weymouth, where it is likewise associated with the same small variety of *Ter. intermedia*. *R. Boueti* is allied to *Rh. trilobata*, Quenstedt. It also bears some resemblance to certain species of Cretaceous *Rhynchonellæ*.

[1] See 'Geol. Mag.,' new series, vol. iv, p. 159, April, 1877.

185. Rhynchonella tetraëdra, *Sow.* Dav., Ool. Mon., p. 93, Pl. XVIII, figs. 5, 9 (not 10, which belongs to *R. sub-decorata*), Pl. XVI, figs. 13, 14; Sup., Pl. XXIX, fig. 6.

Rhynchonella lacunosa, *Dav.* (not of Schlotheim). Ool. Mon., p. 96, pl. xvi, figs. 13, 14, 1852.

I have very little to add to my description of this very abundant and variable species, further than to correct a mistake I made at p. 96 of my Oolitic Monograph, in referring two specimens of *Rh. tetraëdra* to *Rhynch. lacunosa*, Schl. The two specimens in question had been sent to me by the late A. Robertson, of Elgin, as having been procured from the Oxford Clay of Dunrobin. Subsequently, Prof. Judd, having visited the locality, found that these specimens had come from near the top of the Lower Lias (Zone of *Am. oxynotus*, Lias β of Quenstedt), in rocks north-east of Dunrobin Castle, Sutherlandshire, and that it had been found in the same zone, near the village of Tobermory, in the Island of Mull (H. Miller). In England it is quoted by Professor R. Tate from the three upper divisions of the Middle Lias, or Zones of *Am. capricornus*, *A. margaritatus*, and *A. spinatus*. It is a common fossil in the Middle Lias or Marlstone of Straithes, near Whitby, in Yorkshire, and in most of the Liassic localities where the zones above mentioned occur.

In the 'Yorkshire Lias,' p. 421, Prof. Tate expresses the opinion that Quenstedt has figured a series of medium-sized, and young examples of *Rh. tetraëdra* under the name of *R. amalthei* ('Die Brachiopoden,' pl. xxvii, figs. 154—160); but I am not convinced that such is the case, as will be found recorded in my description of *Rh. amalthei*. Professor Tate states that in *Rh. tetraëdra* the beak in the young is sub-erect, not incurved, as in the adult; that the shape is depressed and sub-triangular, and that in the youngest forms traces of the plaits are discernible. He adds that Simpson considers his *Rh. compressa* as probably another variety of *Rh. tetraëdra*, but that he has not seen specimens on which the species is founded. Professor Tate also observes that the species occurs in Yorkshire, in the zone of *Am. armatus* at Robin Hood's Bay, in that of *Am. Jamesoni* at Huntcliff, Coatham, Peak, in the *Am. margaritatus* Zone at Danby Dall, Carlton Moor, Huntcliff, in the *Am. spinatus* Zone in the Cleveland Main Seam, where it is abundant; also at Eston, Upleatham, &c., and Straithes, Grosmont, Millington. It also occurs in the Marlstone of Leicestershire; the young specimens are nearly flat.

It is very variable in shape, and perhaps the following varieties might deserve to be distinguished.

186. Var. *Dumbletonensis*, Dav. Sup., Pl. XXIX, fig. 5.

Some years ago Dr. Wright sent me two examples of a largish *Rhynchonella* which he had found in the Marlstone (Middle Lias) of Dumbleton, near Cheltenham.

In external shape it is sub-pentagonal and nearly as broad as long; the valves are moderately convex and flattened. The dorsal valve, when viewed in profile, presents a slightly convex curve at the umbo, and from there to near the front is nearly straight; close to the front the valve is bent downwards so as to meet the serrated margin of the ventral valve. This valve is almost equally trilobed, the central lobe forming a broad flattened mesial fold, which does not rise very much until near the front. In the ventral valve the sinus is broad, flattened, and of small depth. The surface of each valve is covered with about fifteen ribs, of which six or seven occupy the fold and sinus. The beak is slightly incurved, foramen visible under its angular extremity.

Length 15, breadth 15, depth 10 lines.

This form has all the appearance of being a flattened variety of *Rh. tetraëdra*.

187. Var. *Northamptonensis*, Walker. Sup., Pl. XXIX, figs. 7 to 12.

Mr. J. F. Walker knocked out of a single lump of stone some two hundred examples of this small variety, ranging from 2 lines to 9 or 10 in length. He observed that at 2 lines in length the shell was nearly circular and more or less globular or depressed, the ribs being nearly all the same size, but with age the fold became more and more elevated with two, three, four, or five ribs upon it, a corresponding number being likewise present in the sinus.

It occurs in the Middle Lias of Bugbrook, near Weeden, in Northamptonshire. Apparently adult examples are almost circular or rather longer than wide, spherical from the dorsal valve being exceedingly convex and gibbous, while the ventral one is of much less depth. In this and other respects it differs very materially from the var. *Dumbletonensis* and *R. tetraëdra* proper. In profile the dorsal valve presents a very convex and regular curve, and the mesial fold is well defined and prominent, especially from about the middle of the valve to the front. The beak is much incurved, so that the foramen can be scarcely observed. The surface of each valve is covered with from fifteen to twenty ribs, of which three to five occupy the fold and sinus.

Length 9, width 8, depth 7 lines.

This form is intermediate between *Rh. tetraëdra* and *Rh. amalthei*.

188. Rhynchonella sub-tetraëdra. Dav., Ool. Mon., p. 95, Pl. XVI, figs. 9—12.

Nothing new. It varies very much in shape, and in the number of its ribs. Fine examples occur in the Inferior Oolite of Dundry, and it has been met with abundantly by Professor Buckman and Mr. Darell Stephens in the same formation at Bradford Abbas and its neighbourhood. It also occurs in the Cheltenham district.

189. Rhynchonella amalthei, *Quenstedt.* Sup., Pl. XXVIII, figs. 18, 19, 20, 21?

Terebratula amalthei, *Quenstedt.* Handbuch der Pet., p. 453, tab. xxxvi, fig. 17, 1831.
Rhynchonella — *Oppel.* Die Jura-Formation, p. 188, 1856.
Terebratula — *Quenstedt.* Petrefactenkunde; Deutschlands Brachiopoden, p. 65, tab. xxxvii, figs. 154—161, 1871.

Shell small, sometimes almost globular, about as wide as long; valves moderately or very much convex, even gibbous. Dorsal valve uniformly convex to about half its length, after which a slightly raised mesial fold, more or less defined, with small lateral slopes, extends to the front. Ventral valve rather less deep than the opposite one, with a wide, moderately deep mesial fold, commencing at about half the length of the valve from the beak. Beak small, much incurved, with a small circular foramen under its angular extremity, margined by two narrow deltidial plates. Surface of each valve ornamented with about thirty small, simple, radiating ribs, of which about six or seven occupy the fold and sinus, and become wider and stronger as they approach the front. Proportions variable.

Length and width about 5 lines, depth 4.

Some specimens are not so deep, and others have slightly exceeded the proportions here given.

Obs.—This small shell varies considerably in the respective depth of its valves, as well as in the elevation of its mesial fold; this last is clearly defined in the larger number of specimens, but in some examples, and especially when the valves are very convex, the fold becomes hardly perceptible, and the valve is uniformly convex. *Rh. amalthei* has been well described and figured by Quenstedt, and our British examples agree with the German type. Dr. D. Brauns, in 'Der untere Jura in nordwestichen Deutschland,' places *Rh. amalthei* among his synonyms of *Rh. tetraëdra;* but I think this is a mistake, although I am ready to admit that some young specimens of the last-named shell approach much to Quenstedt's species. *Rh. amalthei,* however, remains the small shell we have described, while *Rh. tetraëdra* attains to comparatively larger dimensions. I am indebted to Dr. Fraas for some typical German specimens, which agreed in every particular with some of those found in England.

Geological Position.—*Rh. Amalthei* was found by the Rev. F. Smithe in the top bed of the *Am. margaritatus* Zone (Middle) Lias at Churchdown in Gloucestershire, also in the *Am. communis* Zone (Upper Lias) at Churchdown Hill. M. E. Deslongchamps, having examined the Rev. F. Smithe's specimens, writes to that gentleman that the species occurs in great abundance in Normandy in the Zones of *Am. margaritatus* and *Am. spinatus;* and that it is remarkable on account of its small size and characters, which partake of those of *Rh. tetraëdra* and *Rh. rimosa*, with the young ages of which it has been often confounded. Mr. J. F. Walker has met with the shell at South Petherton; Mr. Walford obtained it from the *Am. spinatus* Zone at Thenford, near Banbury. In Germany it occurs in the *Margaritatus*-zone at Heiningen, Zell, Ohmenhausen, Balingen, and Breitenbach.

190. Rhynchonella sub-decorata, *Dav.* Ool. Mon., Pl. XVIII, fig. 10, and Appendix to vol. i, p. 21, Pl. A, figs. 23—26.

Nothing new. Inferior Oolite, Cheltenham district.

191. ? Rhynchonella quadriplicata, *Zieten.* Dav., Appendix to vol. i, p. 23, Pl. A, fig. 22; Sup., Pl. XXIX, figs. 1, 2, 3.

Rhynchonella quadriplicata, *Zieten.* Die Verst. Würtemb., pl. xli, fig. 3, 1832.
— — *Desl.* Bull. Soc. Linn. de Normandie, vol. ii, p. 54, pl. v, 1857.

Shell subpentagonal, slightly wider than long. Dorsal valve divided into three lobes, of which the central one forms a large projecting mesial fold, and corresponds with a wide, shallow sinus in the opposite one. Beak much incurved. Surface ornamented with eighteen strong, radiating ribs, of which four usually occupy the fold, while a small and slightly marked additional one is situated on each of the lateral outward slopes of the fold.

Length 18, width 19, depth 11 lines.

Obs.—I am very uncertain with respect to the identification of this shell, which must be considered as provisional. Dr. Wright found the described and figured specimen in the Inferior Oolite at Cleeve Hill, near Cheltenham. It occurs in beds of a similar age at Les Moutiers, Bayeux, and other places in France. Dr. Brauns, in 'Der untere Jura im nordwestlichen Deutschland,' 1871, considers both *Rh. quadriplicata* and *Rh. quinqueplicata* of Zieten to be mere varieties or synonyms of *R. tetraëdra*. At p. 315 of his

'Prodrome,' A. d'Orbigny quotes this species from the Great Oolite, or Étage Bathonien, of different places in France, and at p. 343 of the same work he alludes to it from the Kelloway Rock, or his Étage Callovien; but M. E. Deslongchamps informs us, at p. 54 of the second volume of the 'Bulletin of the Linnæan Soc. of Normandy,' that all these identifications are incorrect, and that he has not found it higher up than the Inferior Oolite.

192. Rhynchonella pygmæa, *Morris*. Dav., Ool. Mon., p. 57, Pl. XIII, figs. 16, 16 *a*, *b*, *c*.

Since publishing my figures and description of this species, I have found that it is referable to the genus *Rhynchonella*, and not to that of *Terebratula*. *Rh. pygmæa* was found by Mr. C. Moore in the Leptæna bed of the Upper Lias near Ilminster, associated with *Ter. globulina*. In 1861 it was also quoted by the Rev. F. Smithe from the zone of *Am. communis* of the Upper Lias of Churchdown, in Gloucestershire. It is not, however, an abundant fossil, or rather, being confined to a narrow area, is not so easily collected. In an admirable paper on the *Ammonites communis* zone published by the Rev. F. Smithe in the 'Proceedings of the Cotteswold Naturalists' Club,' August, 1861, he states "*Rh. pygmæa* is the brachiopod most conspicuously present, followed by *T. globulina* and *Leptænæ*." [1]

[1] The Rev. F. Smithe further observes, "Reference may here be made to the dwarfed size of the organisms of the zone, as though starvelings of a larger race, that came from a distance and struggled for existence. Whether the waters of our Liassic estuary were deficient in a normal percentage of salt is a view not unworthy our consideration. Such a cause would adequately suffice to degenerate the Mollusca inhabiting them. Russian naturalists tell us that while Oysters, for instance, are found in the Mediterranean, the Atlantic, the North Sea, and the northern part of the Cattegat, they do not occur in the Baltic Sea, and refuse to be naturalised there. To accord with this, the Oyster cited in my list is almost a solitary example, not an inch in diameter. The waters of the Mediterranean contain 3·7 per cent. of salt; those of the Atlantic 3 to 3·6 per cent.; the north of the Cattegat 1·8 to 2 per cent.; while the saltest part of the Baltic yields only 1·7 per cent. of salt. In Prof. Forbes's 'Travels in Lycia,' 1847, it is mentioned that a gradual change in fossil marine species of Mollusca was observed by the writer in some coast sections of the Island of Cos. The deviations in form evidently arise from the influx of fresh water. Every algologist must have noticed the stunted dimensions of such marine Algæ as contrive to live in brackish waters, or in salt water commixed with a large proportion of fresh. A specimen of a given plant gathered in pure salt water and placed by the side of the same plant taken from brackish streams would only be recognised as identical by an exceptional botanist conversant with the method of gradation. The waters of the ocean, then, when reduced in their due quantity of saline matter, have undeniably the power of dwarfing the marine forms of animal and vegetable life, and seem to have done so here, transmittng us a puny, diminutive fauna."

193. Rhynchonella Lycetti, *Dav.* Ool. Mon., p. 81, Pl. XV, fig. 6.

Nothing new. Middle division of Inferior Oolite, Minchinhampton; and Oolite-marl, Leckhampton Hill, Cheltenham.

194. Rhynchonella Moorei, *Dav.* Ool. Mon., p. 82, Pl. XV, figs. 11—14.

Prof. Tate, in his table showing the distribution of British Liassic Brachiopoda, 'Geol. Mag.,' December, 1869, quotes this species from the *Am. spinatus* Zone, Middle Lias; also from the Zones of *Am. bifrons* and *Am. jurensis*, Upper Lias.

195. Rhynchonella sub-variabilis, *Dav.* Ool. Mon., p. 80, Pl. XV, fig. 7, and Pl. XVIII, fig. 11.

Rhynchonella sub-variabilis, *De Loriol.* Mon. Pal. et Géol. des Étages sup. Jur. Bas-Boulonnais, p. 239, pl. xxv, fig. 2, 1872.

This shell has been found in the Kimmeridge clay in the Sub-Wealden boring at Netherfield, near Battle, in Sussex; Mr. Seeman obtained it likewise at Hartwell, near Aylesbury. It does not appear to be a very abundant fossil in England, nor is it very common in the middle beds of the Portland of Boulogne-sur-Mer, where I found it for the first time many years ago. M. de Loriol observes that this species is easily distinguishable by its wide compressed shape, and by its sculpture which is formed of radiating striæ intersecting undulating, concentric, slightly raised laminæ.

196. Rhynchonella acuta, *Sow.* Dav., Ool Mon., p. 76, Pl. XIV, figs. 8, 9.

I still adhere to my statement at p. 76 of the 'Oolitic Monograph,' and consider *Rh. acuta* a good and distinct species (as species go, or are viewed by palæontologists). It is easily separable from *Rh. cynocephala*, *Rh. bidens*, and *triplicata*, Phillips, and consequently I cannot agree with the views expressed by Mr. John Jones, of Gloucester, at p. 313, &c., vol. i, of the 'Geologist' for 1858, where he considers the three forms above named to be simple variations in shape of a single species, a view, however, which is reciprocated by Dr. D. Brauns. I do not deny that some rare exceptional examples are

found which may appear to connect these three forms together, but the group so formed may be connected to many other groups in a similar manner, and so on until all the species of *Rhynchonellæ* would disappear. This mode of proceeding, although, perhaps, to some extent correct in the abstract, would not be serviceable to the ends of science.

Rh. acuta has been found by the Rev. F. Smithe near the bottom of the Middle Lias, or *Am. Jamesoni* zone, at Churchdown, in Gloucestershire, and in the *A. margaritatus* zone in the same locality. It has also been quoted by Prof. R. Tate, and others from the *A. spinatus* zone, or top of the Middle Lias. In Yorkshire it occurs in the zone of *Am. margaritatus* (bottom seam of ironstone) at Hutton, Guisborough (Tate), Wilton, Bilsdale (Phillips), Rockcliff (Hutton). Professor Tate found the shell also in the Middle Lias of the Island of Raasay, Scotland. Other localities are recorded in the published description I have given of the species at p. 76 of my Monograph.

197. Rhynchonella cynocephala, *Richard.* Dav., Ool. Mon., p. 77, Pl. XIV, figs. 10—12.

I have nothing to add to the description I have already given of this species; but a few words with respect to its geological position may be here appended. In Yorkshire, the species is stated by Prof. R. Tate to occur at the base of the Inferior Oolite along with *Am. Murchisoni.* In his paper on "New Secondary Brachiopoda" 'Geological Magazine,' vol. vi, December, 1869, it is quoted from the top of the Middle Lias, or Zone of *Am. spinatus* (?), and in the zones of *Am. jurensis* and *Am. opalinus* of the Upper Lias. The Rev. F. Smithe found the fossil in an earthy ferruginous band between two cephalopoda-beds, reposing on the *Am. jurensis* zone, at Haresfield Beacon, in Gloucestershire.

198. Rhynchonella ringens, *Herault.* Dav., Ool. Mon., p. 74, Pl. XIV, figs. 13—16; Sup., Pl. XXVII, figs. 14, 15, 16.

Rhynchonella ringens, *Dav.* Proc. of the Dorset Nat. Hist. and Antiquarian Field Club, pl. iv, figs. 17, 18, 1877.

In England we find a small variety of this species. It has been collected by Mr. Darell Stephens and Mr. J. F. Walker in considerable numbers in the Inferior Oolite at Half-way House near Bradford Abbas, in Dorsetshire. There appears to be a consider-

able difference in the distribution of the species of Oolitic Brachiopoda in the Somersetshire and Dorsetshire areas. As compared with the Cheltenham districts, many species very common in the one district are either very rare or altogether wanting in the other.

199. Rhynchonella sub-ringens, *Dav.* Ool. Mon., p. 75, Pl. XIV, figs. 17, 17 *a*, *b*, *c*.

Nothing new. Inferior Oolite, Somersetshire.

200. Rhynchonella Bouchardii, *Dav.* Ool. Mon., p. 82, Pl. XV, figs. 3—5; Sup., Pl. XXIX, fig. 19.

This species occurs in a thin band of clay in the Upper Lias (zone of *Ammon. bifrons*) in the neighbourhood of Ilminster.

201. Rhynchonella oolitica, *Dav.* Ool. Mon., p. 81, Pl. XIV, fig. 7.

Nothing new. Pea-grit, Inferior Oolite, Cheltenham district.

202. Rhynchonella Forbesii, *Dav.* Ool. Mon., p. 84, Pl. XVII, fig. 19.

Rhynchonella Forbesii, *Dav.* Proc. of the Nat. Hist. and Antiquarian Field Club, pl. iv, fig. 15, 1877.

Several characteristic specimens of this small globular species have been collected by Mr. D. Stephens from the Inferior Oolite of Bradford Abbas, in Dorsetshire.

203. Rhynchonella concinna, *Sow.* Dav., Ool. Mon., p. 88, Pl. XVII, figs. 6—12; Sup., Pl. XXVII, fig. 22.

This species occurs chiefly in the Great Oolite and Stonesfield Slate near Oxford, and

elsewhere. It is found also in the Bradford Clay at Tetbury-Road Station; and in the Cornbrash of Yaxley, near Peterborough; where it is associated with *Rh. Leedsii.*

204. *Var.* Yaxleyensis, *Dav.* Sup., Pl. XXVII, fig. 23.

This is an extreme and well-marked variety, or rather variation in shape, of *Rh. concinna,* in which the frontal portions of the valves are very much thickened; each valve, as it approaches the serrated frontal margin, is more or less suddenly or abruptly bent at nearly right angles, giving to the frontal view of the shell a broad, square, flattened character. The ribs are also to some distance from their extremities grooved along the middle, as is seen in *Rh. octoplicata, Rh. Wilsoni,* and many other species. This shell does not appear to have much exceeded 9 lines in length by 10 in breadth and 7 in depth. It occurs in great abundance, along with typical examples of *Rh. concinna,* in the Cornbrash at Yaxley, near Peterborough. It is associated with several varieties of *Wald. obovata, Ter. Bentleyi,* and *Rh. Leedsii.*

205. Rhynchonella sub-concinna, *Dav.* Ool. Mon., p. 90, Pl. XVII, fig. 17.

This shell occurs in the upper portion of the Middle Lias (Zones of *Am. margaritatus* and *A. spinatus*). Professor R. Tate quotes it in the 'Yorkshire Lias' from the Zones of *Am. Jamesoni,* at Huntcliff, Peak, and *A. capricornus,* Huntcliff (?) Yorkshire. It is still a question whether *R. fodinalis,* Tate, is specifically distinct from *R. sub-concinna.*

206. Rhynchonella fodinalis, *R. Tate.* Sup., Pl. XXVIII, figs. 39, 40, 41.

Rhynchonella fodinalis, *R. Tate.* The Yorkshire Lias, p. 424, pl. xv, fig. 16, 1867.

Shell transversely oval or obovate, wider than long; dorsal valve moderately convex, deeper than the ventral one; margin in front rising with a gentle undulation; lateral margins rounded; fold of moderate elevation occupying less than a third of the breadth of the anterior half of the valve; beak in ventral valve acutely pointed, incurved, with a small foramen situated under its acute termination and the hinge-line, from which it is but little separated by its small deltoidial plates; beak-ridges sharply defined, leaving between them and the hinge-line a long, narrow, flattened space or false area. Sinus

moderately deep. Surface of valves covered with from twenty-five to thirty-six sharp angular ribs, of which from six to eight occupy the fold and sinus. The ribs are also closely intersected by small projecting lines of growth. Two specimens measured—

Length 7, breadth 7½, depth 5 lines (one of Tate's original Yorkshire specimens). „ 9, „ 12, „ 7 „ (a Banbury specimen).

Obs.—Professor Tate remarks that "this may be the species alluded to by Young and Bird as *Ter.* [*Rh.*] *depressa*, Sow., which they state has nearly the same form as their *T. compressa*, which is amply described by them." It cannot be denied that a very close resemblance exists between it and the Cretaceous species, so close, indeed, that some of the specimens could hardly be distinguished. Professor Tate considers it to be a new species, but a study of more specimens is requisite to finally determine whether *Rh. sub-concinna* and *R. fodinalis* are really distinct species; some middle-sized specimens of both in my collection could scarcely be separated. While looking over Mr. Beesley's collection at Banbury, Professor Tate was surprised to find that specimens from the *Am. spinatus* Zone (Middle Lias) of the neighbourhood of Banbury were much larger and finer than those he had collected from the *Am. spinatus* Zone of Eston, Stapeworth, and Guisborough, in Yorkshire.

207. Rhynchonella obsoleta, *Sow.* Dav., Ool. Mon., p. 90, Pl. XVII, figs. 1—5; (and Var.) Sup., Pl. XXIX, fig. 4.

This species occurs chiefly in the Great Oolite and Bradford Clay; but a number of specimens apparently undistinguishable from those occurring in the Great Oolite have been met with by Mr. Darell Stephens in the Inferior Oolite of Bradford Abbas and Crewkerne Station, Dorsetshire, and at some other localities.

208. Rhynchonella sub-obsoleta, *Dav.* Ool. Mon., p. 91, Pl. XVII, fig. 14.

Inferior Oolite Marl, Hartley Bottom. It was also found in the same formation by Mr. J. F. Walker at Peak, Yorkshire Coast.

209. Rhynchonella angulata, *Sow.* Dav., Ool. Mon., p. 92, Pl. XVII, fig. 13.

At p. 92 of my Oolitic Monograph I described this species. Sowerby's figures of it in the 'Mineral Conchology' are not good; but I was able to draw the original example

which had been procured from an ochraceous limestone (Inferior Oolite) at Cleeve Hill, near Cheltenham.

210. *Var.* SUB-ANGULATA, *Dav.* Sup., Pl. XXIX, figs. 14, 15, 16.

This variety occurs abundantly in the Pea-grit (Inferior Oolite) at Leckhampton Hill, and in the same formation at Bradford Abbas, in Dorsetshire. The mesial fold is considerably more elevated than in the typical forms of Sowerby's species. When the smaller valve of *Rh. angulata* is viewed in profile, it presents a regular convex curve, while in the variety *sub-angulata* the same valve in profile is almost straight or very slightly convex, and is even a little bent upwards near the front, as in *Rh. varians*. It is also more sub-pentagonal, and broader than long; the hinge-line presents a long and very obtuse angle. From twenty to twenty-four angular ribs cover each valve, of which three or four occur on the fold and sinus, these last being somewhat larger or stronger than those on the lateral portions of the valve. An average-sized example measured—

Length 8, width 10, depth 6 lines. It seems to be pretty constant in shape.

211. RHYNCHONELLA VARIABILIS, *Schloth.* Dav., Ool. Mon., p. 78, Pl. XV, figs. 8—10.

Palæontologists seem to differ considerably in their views with respect to this species. There can, however, exist no uncertainty with regard to the small shells we have figured (figs. 8, 9, 10), for they agree in shape, size, number of ribs, and every other particular, with the specimen figured by Schlotheim in 'Leonhard's Mineral. Tasenbuch.' for the year 1813. Schlotheim's figure, as well as ours, shows that the ribs composing the mesial fold are slightly turned upwards close to the margin, as is seen in figs. 9 and 10 of our plate. Now, this feature is rarely observable, as far as I am aware, in the larger shell to which Young and Bird gave the name of *T. lineata*, and Phillips those of *T. bidens* and *T. triplicata*. Dr. D. Brauns, in his valuable work 'Der unter Jura im norwestlichen Deutschland,' p. 436, 1871, gives a very long list of synonyms, but I fear few are applicable to the species under description.

Rhynchonella variabilis, thus restricted, was first found by myself in the Lias near Radstock, and subsequently by Mr. E. B. Tawney in the same neighbourhood. He also quotes it from the Lower Lias ('Bristol Naturalists' Society' Proceedings, vol. i, part 2, p. 189, 1871).

212. RHYNCHONELLA LINEATA, *Young and Bird.* Dav., Ool. Mon., Plate XVI, figs. 1 and 3 (only); Sup., Pl. XXIX, figs. 17, 18.

TEREBRATULA LINEATA, *Young and Bird.* Geol. Survey of the Yorkshire Coast, p. 232, pl. viii, fig. 10, 1828.

— TRIPLICATA and T. BIDENS, *Phillips.* Geol. of Yorkshire, pl. xiii, figs. 22—24, 1829.

RHYNCHONELLA VARIABILIS, var. *Dav.* British Ool. Brach., p. 78, pl. xvi, figs. 1 and 3, 1852.

— TRIPLICATA, *Simpson.* Foss. Yorkshire Lias, p. 131, 1855.

RHYNCHONELLA LINEATA, *Tate.* The Yorkshire Lias, p. 421, pl. xv, figs. 21, 22, and 23, 1876.

This is a much larger shell than *R. variabilis* proper, and since Messrs. Tate and Blake have devoted so much attention to the shell in question in their admirable work on the "Yorkshire Lias," we may as well reproduce Professor Tate's description.

"Adult forms of this species have a resemblance to *R. tetraëdra*, but differ in the number and character of the plaits, and in the larger, less incurved beak, and large foramen. There are invariably two or three plaits on the mesial fold, with from three to four on each lateral area of the brachial valve which are all evanescent towards the umbo. Phillips distinguished two forms, that with three plaits as *triplicata*, and that having two on the mesial fold as *bidens*. . . . Young and Bird's description and figure belong to the *bidens* form; and as there can be no doubt respecting the shell figured by them, supplemented by a sufficiently full description, I adopt their name in accordance with the rule of priority. The description reads as follows: 'No. 10 is a small shell, very common in the ironstone bands and in the Dogger; it differs from *T. tetraëdra* not only in being smaller, but in having only two elevated plaits at the base, and a sunk line on the lesser valve, running from the beak to a groove between these plaits. There are about four plaits on each side of the beak, besides those of the base.' As regards size, however, it not unfrequently equals the largest specimens of *Rh. tetraëdra*."

Professor Tate then alludes to the denticulated sockets (Sup., Pl. XXIX, fig. 18), "a character which also belongs to *R. rimosa* and *R. acuta*; *vide* Quenstedt's 'Die Brachiopoden,' t. xxvii, figs. 107 and 151. The young shells are depressed, broadly subtriangular; the front edge of the united valves is at first straight, but gradually becomes arched as the shell is enlarged; no trace of plication is presented by specimens up to half-an-inch in breadth. The beak is erect, and the foramen large. There is no other alternative between regarding these small shells as the young of *R. lineata* and assigning them to a new species, as they are found in company with *R. lineata* in the shales below

the main ironstone seam, the only species of the genus occurring therein. The smallest specimen showing plications is three quarters of an inch broad, but still retains the depressed shape of the juvenile examples. Examples of *Rh. tetraëdra* at this stage have already been described, whilst young specimens of *Rh. acuta*, with a diameter of three eighths of an inch, present a strong mesial fold and lateral plications. I cannot agree with Simpson, who considers the species related to *Rh. tetraëdra* rather than *Rh. variabilis*, and still less with Brauns, who places it with *Rh. cynocephala* under *Rh. acuta*."

"Geological position.—Zone of *Am. spinatus*. Very abundant in the shaly ironstone called the 'Cockle Band,' at the base of the Cleveland Main Seam at Eston; also in the Main Seam, Eston, Upleatham, Straithes, Runswick, Hawsker, &c."

213. Var. *Radstockiensis*, Dav. Ool. Mon., Pl. XVI, figs. 4 and 6.

This is a variety of *Rh. lineata*, intermediate in size and shape between *Rh. variabilis* and *Rh. lineata*. It occurs plentifully in the Middle Lias, at Clandown quarries, Radstock, and Churchdown in Gloucestershire. It is a squarer, more regularly convex, and smaller shell than *Rh. lineata* proper, and its young are very different from those of the typical form.

It has generally three ribs on the mesial fold, and five on each of the lateral lobes.

It rarely exceeds, or even attains, 10 lines in length, by the same in width, and 8 in depth. In Pl. XV of my Monograph of Oolitic and Liassic species I have given two figures showing the characters of this variety.

214. Rhynchonella oxynoti, *Quenstedt*. Dav., Sup., Pl. XXVIII, figs. 37, 38.

Terebratula oxynoti,		*Quenstedt*.	Handbuch der Petref., p. 451, pl. xxxvi, figs. 4, 5, 1851.
—	—	*Quenstedt*.	Der Jura, p. 112, tab. xiii, figs. 22, 23, 1858.
—	—	*Quenstedt*.	Die Brachiopoden Pet. Deuts., pl. xxxvii, figs. 60, 61, 1871.
Rhynchonella	—	*R. Tate*.	Additions to the List of Brach. from the Sec. Rocks, Geol. Mag., vol. vi, p. 553, 1869.

Shell small, subpentagonal, slightly broader than long, widest anteriorly, tapering posteriorly to a pointed beak. Valves moderately convex; dorsal valve smooth to about one third or more of its length from the umbo, afterwards divided into three lobes; the central one forms a sharply defined mesial fold with wide lateral slopes; two or three small longitudinal ribs cover the upper portion of the fold, while three or four short and

stronger ribs occupy the surface of each of the lateral lobes. Ventral valve not quite so deep as the opposite one, with a sharply defined median sinus; eight or nine short ribs cover the surface of this valve, the beak of umbonal portion remaining smooth; one or two short ribs occupy the central portion of the sinus, the remainder the lateral portions of the valve; beak pointed, incurved, foramen situated under its extremity and margined by small deltidial plates.

Length 5, breadth 6, depth $3\frac{1}{2}$ lines.

Obs.—Through the kindness of Dr. Fraas, of Stuttgard, and the late Dr. Oppel, I have been able to examine typical German examples of this species from the lower portion of the Middle Lias of Balingen and Ofterdingen. This species and *Rh. Amalthei* were discovered by Dr. Fraas, and given by him to Professor Quenstedt to name and describe. I compared these German types with specimens from the upper portion of the Lower Lias of the Aston cutting, Northamptonshire, in the Museum of the School of Mines, and with others found by the Rev. F. Smithe in the *Am. oxynoti* Zone of the Lower Lias, at Churchdown, in Gloucestershire, as well as with some smaller specimens from Hallaig, in the Isle of Skye, given to me by Professor Tate, and arrived at the conclusion that the British examples agreed with those from Germany.

I believe that several of the described German so-termed species should be united to the one under description, but as I do not possess authentic types of some of them I should not like to write out a list of the synonyms. It appears to me that *Rh. ammonitica* and *Rh. gryphitica* of Quenstedt may perhaps be united to *Rh. oxynoti*, from their having the rostral third of each valve smooth; they could not be so well located with either *Rh. calcicosta* or *Rh. plicatissima*. Professor Tate adds *T. maceana*, d'Orb. ('Prod.,' p. 221, 1850), *Rh. Buchii*, Chapuis et Dewalque (1854), and *Rh. ranina*, Suess (1860), to the synonyms of *Rh. oxynoti*.

215. Rhynchonella triplicata juvenis, *Quenstedt*. Dav., Ool. Mon., Pl. XVI, figs. 2 and 5 (not *Rh. variabilis*); and Sup., Pl. XXVIII, figs, 35, 36.

Terebratula triplicata juvenis, *Quenstedt*. Handb., p. 451, pl. xxxvi, fig. 2, 1851.
— — — *Quenstedt*. Der Jura, p. 74, pl. viii, figs. 16—23, 1858.

Shell small, subpentagonal, or oval, about as wide as long. Dorsal valve moderately or greatly convex, smooth to about two thirds of its length, whence from four or nine marginal ribs extend to the front and margin of the shell; two or three of these ribs form a short mesial fold. Ventral valve smooth, likewise, to within a short distance of the margin, sinus moderately deep, beak incurved, foramen minute, proportions variable.

Length 6, width $5\frac{1}{2}$, depth 4 lines.

Obs.—In 1852 I described two specimens of this small species as varieties of *Rh. variabilis*, but having subsequently seen a number of German types, and a very good series of figures by Quenstedt in pl. viii of his 'Der Jura,' I now perceive the necessity of separating it from Schlotheim's species. I have figured two examples from a number of British specimens from the Lower Lias of Stonehouse, which appear to correspond exactly with some of Quenstedt's figured species. Our fig. 35 agrees with his fig. 19, my fig. 36 with his fig. 17, and, indeed, I could have matched all his other figures with British specimens. Therefore, I believe, we may consider the identity established.

Many of the specimens seem also to approach *Rh. oxynoti* in shape; and *Rh. triplicata juvenis* is certainly related to that species.

216. Rhynchonella varians, *Schlotheim*. Sup., Pl. XXVIII, figs. 3 a, 3 b, 4, 12, and 13.

Terebratula varians, *Schlotheim*. Die Petrefactenkunde, p. 267, and for figure, Brugnière Encycl. Meth., pl. ccxli, figs. 5, 6, 1820.

This species was not sufficiently described by Schlotheim, and the figure in the 'Encyclopedie Méthodique,' pl. ccxli, fig. 5 (fig. 12 of our Plate), to which he refers, leaves some uncertainty with respect to its real characters. Schlotheim states that his fossil was obtained at Amberg.

In 1834, in his work 'Ueber Terebrateln,' pl. i, fig. 19, Baron von Buch gave a profile view of what he considered to be the *Tereb. varians*, observing at the same time that the shell is easily distinguishable from its congeners, above all by the manner in which the smaller valve rises on leaving the hinge; that the valve rises first by a gentle curve, hardly perceptible, at an angle of 45°, to near the middle of the valve; it then rises more abruptly, and afterwards, on approaching the front, becomes rapidly bent so as to meet the serrated margin of the opposite valve. He added likewise that it occurs in the upper portion of the Middle Jurassic formation of Germany, and that the bed containing this fossil is rarely absent when one approaches the great white band which represents the Upper Jurassic formation.

Rh. varians, as we understand it, would form a group consisting, in England, of three or four varieties, which, although differing but slightly, mark different geological horizons; so that without attaching any exaggerated importance to the varieties, which, although useful in a certain sense as indicating distinct geological horizons, do not seem persistent, I feel persuaded that the typical form of *Rh. varians*, as it is generally understood, has continued to be represented from the Fullers' Earth up to the Lower Calcareous Grit,

inclusive. It is also probable that the shell which occurs in the Kelloway Rock of Scarborough may represent the type of Schlotheim's species.

217. Var. *Smithii*, Walker. Dav., Ool. Mon., p. 83, Pl. XVII, figs. 15, 16; Sup., Pl. XXVIII, figs. 1, 2, 3.

TEREBRATULA MEDIA, *Smith* (not *T. media* of Sowerby). Strata Identified by Organised Fossils, p. 32, plate facing p. 32, fig. 9, 1816.

Shell somewhat obscurely triangular, broadest anteriorly, and laterally rounded, tapering posteriorly, wider than long. Dorsal valve most convex, and anteriorly divided into three lobes, of which the central one forms a more or less elevated fold. When seen in profile this valve is slightly convex at the umbo, from whence it is nearly straight to within a short distance from the front, when it assumes a slightly upward curve; it is then abruptly bent downwards to meet the serrated frontal margin of the opposite valve. The ventral valve is moderately deep and convex, the lateral portions being slightly curved upwards near the margin. The sinus is wide and of moderate depth, beak small, incurved, with a small circular foramen under its angular extremity, and margined laterally by two narrow deltidial plates. The surface of each valve is ornamented with about twenty-six small angular ribs, of which some six compose the fold and sinus; the ribs are also longitudinally indented along the middle for some distance from their extremities. An average-sized specimen measured—

Length 7, width 8, depth 5 lines.

Obs.—It is much to be regretted that Smith did not, in 1816, describe this shell with a new name, instead of erroneously identifying it with *Ter. media* of Sowerby. Smith states that he found the shell under description in the Fullers' Earth, near Bath, at Charlton, Harethorn, Orchard Leigh. It is immensely abundant in the Fullers' Earth of Great Britain, and wherever that formation occurs. It may be collected at Whatley near Frome, Powerstock near Bridport, Burton, &c., and the specimens from all these and other Fullers' Earth localities closely resemble each other.

In Pl. XVII, figs. 15, 16, will be found correct figures of this variety. It cannot, however, be denied that specimens very similar to those found in the Fullers' Earth occur higher in the series, and even as far up as the Lower Calcareous Grit. A specimen from the Oxford Clay, in the Oxford Museum, is indistinguishable. This variety has been named by Mr. Walker, after its first discoverer, the distinguished author of the work above noted.

218. Var. *Socialis*, Phillips. Sup., Pl. XXVIII, figs. 8 to 11.

TEREBRATULA SOCIALIS, *Phillips*. Geol. of Yorkshire, part i, p. 112, pl. vi, fig. 8, 1829.

Shell somewhat transverely oval, wider than long. Valves very convex, especially the dorsal one, and forming in profile a regular convex curve from the extremity of the umbo to the frontal margin. A well-defined and rather broad mesial fold gradually rises at about half the length of the valve from the umbo. The ventral valve is divided by a wide shallow sinus commencing at about the middle of the valve, and extending to the serrated frontal margin of the opposite valve. Beak much incurved. Surface of each valve marked with a variable number of rather strong, angular ribs; from sixteen to eighteen in each valve, of which about five occupy the fold and sinus.

Length 8, width 10, depth 7 lines.

Obs.—Phillips's figure denotes a shell exceeding in size the usually small var. *Smithii* from the Fullers' Earth. The longitudinal, regular, convex curve of the dorsal valve, and its strong ribs, distinguish it from the other varieties of this variable species. This is the shell represented by Phillips's figure. Many examples can be obtained from the Kelloway Rock of Scarborough. We should, in our discrimination of a species or variety, bear in mind the characters assigned to it by its proposer. Along with the var. *socialis*, in the same rock and locality, are found specimens closely resembling the typical *Rh. varians*, which, as we have already stated, may be the shell so named by Schlotheim. Some specimens approach, likewise, to the variety that occurs in the Oxford Clay, near Scarborough, specimens of which may be seen in the York Museum.

219. Var. *spathica*, Lamarck? Sup., Pl. XXVIII, figs. 5, 6, 7.

TEREBRATULA SPATHICA, *Lamarck* (pars). Anim. sans Vert., tom. vi, p. 256, 1819; and Dav., Exam. of Lamarck's Species of Fossil Terebratulæ, Annals and Mag. Nat. Hist., 2nd ser., vol. v, 1850.

RHYNCHONELLA — *Oppel*. Die Jura-Formation, p. 576, 1857.

— — *E. Desl.* Bull. de la Soc. Linn. de Normandie, tom. iv, p. 246, 1859; and Mém. Soc. Linn. de Normandie, vol. xi, 1859.

This variety, as determined by M. E. Deslongchamps, is more circular and spherical, or regularly convex, than the var. *Smithii*, and less transverse than the following variety called *Thurmanni;* the fold in the dorsal valve does not rise in so marked or

prominent a manner as is the rule in the var. *Smithii*, and the ribs are more numerous and smaller than in the var. *socialis*. The beak is very much incurved, so that the foramen is almost entirely concealed. The largest example I have seen measured $8\frac{1}{2}$ lines in length, by about the same in breadth, and 6 in depth.

Mr. E. Deslongchamps observes, in his description of this shell, that it so closely resembles *Rh. tetraëdra* from the Lias, that it might be taken for that shell; but if one examines a numerous suite of specimens, it is seen at once that var. *spathica* is much closer to *Rh. varians*.

In my paper on "An Examination of Lamarck's Species of Fossil Terebratulæ," I mentioned that Lamarck gives no reference to any figure, but states that his specimens came from the hills on the boundary of the Sarthe; and I was at a loss to know what is the type of his species, not from want of specimens, but from the number of different species placed under one head in the Lamarckian Collection. There were thirty specimens, referable to *Rh. tetraëdra*, *Rh. concinna*, *Rh. varians*, *Rh. rimosa*, and perhaps another.

Whatever may be the form intended by Lamarck, M. E. Deslongchamps figures, as one of the types of *Rh. spathica*, a specimen from the lower portion of the Oxford Clay of the Wast in the Boulonnais, and this agrees in every particular with those we find in the *Am. cordatus* zone of the Oxford Clay at St. Ives, in Huntingdonshire, and in the Kelloway Rock of Kelloway. *Wald. impressa* seems to accompany it in the same bed. Fine examples have been collected by Mr. James Parker from the Oxford Clay of Summertown, and St. Clements, Oxford; and good examples may be seen in the Oxford Museum. We will therefore consider this variety to represent the *Rh. spathica* and retain the name.

220. Var. *Thurmanni*, Voltz. Sup., Pl. XXVIII, figs. 14, 15, 16.

Terebratula Thurmanni, *Voltz*. E. Thirria, Statistique Mineralogique et Géologique du Dépt. de la Haute-Saône, pp. 172 and 179, 1833.

— — *Bronn*. Lethæa Geog., p. 29, 1835.

Rhynchonella Thurmanni, *Étalon*. Lethæa Brutrutana, p. 291, pl. xlii, fig. 6, 1861.

— — *J. F. Walker*. Geol. Mag., 2nd ser., vol.ii, p. 572, 1875.

This shell has been considered by Mr. J. F. Walker and some other palæontologists as a variety of *Rh. varians*, and as distinguishable from the var. *Smithii* and var. *spathica* by its larger size and greater breadth when compared with its length; it is also less spherical than the variety *spathica*, to which, however, it approaches

so closely that it is questionable whether it can be satisfactorily distinguished. A large specimen in Mr. Walker's collection measured—

Length 9, breadth 10, depth 6 lines.

In England it has been found by Mr. Walker in the Lower Calcareous Grit (a friable yellow rock) at Castle Howard, in Yorkshire. Both the rock and specimens agree completely with those found in about a similar stratigraphical position at St. Remi, Ardennes, in France. It is also stated by Mr. Walker to occur at Filey, on the Yorkshire coast, in the Passage-beds of the Lower Calcareous Grit, and at Appleton, near Malton.

221. Rhynchonella Leedsii, *Walker*, MS. Sup., Pl. XXVIII, fig. 17.

Shell spherical, almost circular, nearly as long as broad; valves very convex. Dorsal valve evenly convex to within about two thirds of its length, when a broad mesial fold commences to rise, but very slightly above the regular convexity of the valve. The sinus in the dorsal valve is wide and shallow; beak small, pointed, incurved; foramen slightly separated from the hinge-line by narrow deltidial plates. Surface ornamented with about thirty small angular ribs or plaits, of which eight or nine occupy the fold and sinus. A large example measured—

Length 7½, width 8, depth 6 lines.

Obs.—As observed by Mr. Walker, *Rh. Leedsii* differs considerably from *Rh. varians* in being a rounder and more globose shell. In full-grown examples the ribs become obsolete on the umbone and beak, and the beak-ridges are less strongly marked. In profile also *Rh. Leedsii* forms a regular convex curve, while in *Rh. varians* the curve is regularly convex at the umbone, and to about half the length of the valve, when it becomes slightly concave, becoming more elevated and convex again near the front.

Mr. J. F. Walker has named this species after his friend C. E. Leeds, Esq., M.A., Oxford, who has been working at the palæontology of Peterborough, where he has found some new Reptiles. *Rh. Leedsii* is a common shell in the Cornbrash of Yaxley, near Peterborough, and was also met with by Messrs. Leckenby and Walker in the same formation near Scarborough, in Yorkshire. This species has been confounded with *Rh. varians* and other Oolitic species of *Rhynchonella*.

222. Rhynchonella egretta, *E. Desl.* Sup., Pl. XXVIII, fig. 23.

Rhynchonella egretta, *E. Desl.* Bull. Soc. Linn. de Normandie, vol. iii, pl. iv, figs. 4 to 6, 1859.

Rhynchonella Egretta, *C. Moore.* Somersetshire Archæol. and Nat. Hist. Soc., vol. xiii, 1865-6; and Quart. Journ. Geol. Soc., vol. xxiii, p. 477 1867.

Shell small, about as long as wide; valves moderately convex and somewhat flattened. Dorsal valve divided into three almost equal portions, the central one forming a wide, slightly raised and flattened fold. Ventral valve a degree deeper than the opposite one; sinus wide, of small depth; beak pointed, incurved; foramen small. Surface of valves ornamented with a variable number of ribs, of which about twelve may be counted on each valve, three or four occupying the fold and sinus. Proportions variable; a large specimen measured—

Length 8, width 8, depth 5 lines.

Obs.—This species has been well described and figured by M. E. Deslongchamps, and was found by him in the bed containing *Leptæna Davidsoni* at May, near Caen, in Normandy, where it was rather abundant. In England it was found by Mr. C. Moore at Whatley, in the representative of the Fontaine-Étoupe Lias, and some specimens in the Museum of the School of Mines in London are labelled Middle Lias, Chideock.

223. Rhynchonella (?) Lopensis, *Moore.* Sup., Pl. XXVII, figs. 8, 9.

Rhynchonella Lopensis, *Moore.* Proceedings of the Somersetshire Archæological and Nat. Hist. Soc., p. 114, pl. i, figs. 9, 10, 1855.

Shell small, flattened, thickest at the umbone, triangular, nearly straight in front, from whence it tapers to the beak. Deltidium triangular. Dorsal valve slightly concave. Ventral valve proportionately convex.

"This little species is from a bed of blue Oolitic Marl occurring in the neighbourhood of Lopen, near Ilminster, where it is rare. In Mr. Davidson's Appendix (vol. i, p. 30) it is named *R. triangularis*, but that name having been previously adopted by Wahlenberg it has been altered." (Moore.)

Obs.—I have seen two examples of this shell, the largest being two lines in length by nearly three in width. Mr. Moore's figures give a faithful general representation of his shell, but I fear it is not a *Rhynchonella*. The ventral valve is generally convex and carinated, while the dorsal one is much depressed; the beak triangular and pointed. I could notascertain the exact form or position of the foramen. Both valves are very much flattened, so that there is only a small space left between the valves for the accommodation of the animal.

224. Rhynchonella (?) coronata, *Moore*. Sup., Pl. XXVII, fig. 13.

Rhynchonella (?) coronata, *Moore*. The Geologist, vol. ii, p. 191, pl. ii, figs. 23—25, 1861.

Both this and the preceding fossil have all the appearance of being the fry of some species not at present determined. The character of the beak would evidently lead to this conclusion; and, indeed, I might also express the same suggestion with respect to the minute shells described by Mr. C. Moore under the designations of *Spiriferina minima* and *Sp. Oolitica*. M. E. Deslongchamps even questions the value of the genus *Zellania*, and is under the impression that all the species referred to it are the fry of some other species, of which full-grown specimens occur in the same rocks. This is, however, a question requiring further investigation, and therefore it will be preferable, provisionally at any rate, to retain Mr. C. Moore's genus and species. Mr. C. Moore describes his *Rh. coronata* in the following words:

"Shell small, smooth, rounded; ventral valve rather convex; dorsal valve more flattened, and with a slight sinus; beak produced, with a large triangular deltidium, bordered by a narrow area, from which spring two raised, lateral, ear-like processes, which again fold over upon the area. Under the above the valve possesses strongly marked hinge-beak. The shell is from the Upper Lias of Ilminster, whence I have nine examples. The lateral ear-like expansions give it a very peculiar appearance. With some little doubt it is referred to the genus *Rhynchonella*, though the shell-structure appears to agree most with that genus."

Obs.—This shell was badly drawn in the 'Geologist;' there exists a narrow depression all along the middle of the dorsal valve, as will be seen in the more correct drawings I have made from Mr. Moore's specimens. His figures are likewise too square. Prof. Tate quotes it from the zone of *Am. jurensis*.

225. Rhynchonella Tatei, *Dav*. Sup., Pl. XXVIII, fig. 45.

Shell small, transversely oval, or wider than long. Dorsal valve more convex and deeper than the ventral one, and divided into three lobes of about equal breadth, the central one forming a wide, slightly raised mesial fold. Ventral valve with a broad, shallow sinus; beak pointed, incurved; foramen minute, and separated from the hinge-line by its small deltidial plates; surface of both valves ornamented by about eighteen small ribs, of which about six occupy the mesial fold.

Length $4\frac{1}{2}$, breadth 5, depth $3\frac{1}{2}$ lines.

Obs.—This species is of about the same size as *Rh. amalthei*, but it differs from it in the regularity of its ribs, which do not widen as they near the margin. Professor R. Tate, who sent me this fossil, believes it to be new to England, and states that it is very abundant in the Inferior Oolite Marl at Seven Springs, Cubberfield, and the south side of Ravensgate Hill, near Cheltenham.

226. Rhynchonella subserrata, *Münster*.

Rhynchonella fallax, *Deslongchamps*. Bull. Soc. Géol. de Normandie, vol. vii, pl. iii, figs. 1—5, 1863.

This species is quoted by Prof. R. Tate as having been found in Great Britain ('Geol. Mag.,' vol. vi, Dec., 1869), but I have not seen the fossil; and, as he specifies no locality, I can only reproduce his statement.

227. Rhynchonella parvula, *E. Desl.* Sup., Pl. XXVII, fig. 21.

Rhynchonella parvula, *E. Desl.* In Terry, Mém. Soc. Linn. de Normandie, t. xii (Note sur l'Étage Bajocien des Environs de Macon, p. 22, 1860); Études critiques sur des Brachiopodes nouveaux ou peu connus, parts 1 and 2, p. 29, pl. v, figs. 5, 6, 1862.

Shell small, subpentagonal, wider than long, dorsal valve flattened and very slightly convex, divided into three, almost equal lobes, of which the central one forms a wide, flattened, and sharply defined mesial fold. Ventral valve deeper and more convex than the opposite one, with a wide, shallow sinus, the central portion of which is occupied by two longitudinal, angular ribs, one being present on each of the lateral portions of the same valve. Beak small, prominent, with a largish circular foramen, margined and slightly separated from the hinge-line, by a well-defined deltidium. The beak-ridges are sharply marked, leaving a flattened space between them and the hinge-line.

Length 4, width 5, depth 2 lines.

Obs.—This elegant small shell exactly resembles the figure given by M. E. Deslongchamps of his *Rh. parvula*. A few specimens of it were obtained by Mr. Darell Stephens at Bradford Abbas, in Dorsetshire, where it does not appear to have exceeded the dimensions above given. It is recorded by M. Deslongchamps, from the Inferior Oolite of Milly (Saône-et-Loire), also from Conlies (Sarthe), and Argenton (Indre).

228. Rhynchonella Stephensi, *Dav.* Sup., Pl. XXVII, fig. 20.

Shell small, transversely oval, broadest posteriorly, tapering anteriorly, valves almost equally deep. Dorsal valve smooth, and uniformly convex to about two thirds of its length, when a wide biplicated fold is produced along with two or three wide but short ribs on each of the lateral submarginal portions of the valve. In the dorsal valve a wide and deep sinus extends from the middle of the valve to the front, with one central rib. Two or three short ones also occupy the lateral portions of the valve. Beak small, incurved; foramen minute.

Length 4, width 5, depth $2\frac{1}{2}$ lines.

Obs.—Mr. Darell Stephens found two examples of this small, but well-marked, species in the Inferior Oolite at Crewkerne Station, near Sherborne. It bears some resemblance to one or two *Rhynchonellæ* described by Messrs. Chapuis and Dewalque, from the Lias of Luxemburg, but differs from them in size and other respects, also in stratigraphical position; and, as I could find no named species from the Inferior Oolite with which to identify it, I have thought it preferable to give it a separate designation.

229. Rhynchonella calcicosta, *Quenstedt.* Dav., Sup., Pl. XXVIII, figs. 24—33.

Terebratula calcicosta, *Quenstedt.* Handbuch Petrefact., p. 451, pl. xxxvi, figs. 6—9, 1851.
— — *Quenstedt.* Die Jura, p. 138, pl. xvii, figs. 16, 17, 1858.

Shell more or less subtrigonal or subpentagonal, as broad as long, or a little wider than long. Dorsal valve divided into three lobes, the middle one forming a moderately raised, flattened, mesial fold. Sinus in ventral valve wide; beak much incurved; foramen small, not always visible, margined by small deltidial plates. Surface marked with strong ribs, from fourteen to twenty in number, which radiate direct from the extremity of the beak to the margin; two to six form the mesial fold and sinus. When young the shell is almost circular, and uniformly convex, without any fold or sinus, and with almost equal-sized ribs. Occasionally a shorter rib is interpolated between two larger ones; and the shell is, as an exception, sometimes slightly longer than wide. Proportions variable—

Length 6, width 7, depth $4\frac{1}{2}$ lines.

Obs.—Two closely allied species, or varieties, have been described and figured by Quenstedt, under the designation of *calcicosta* and *plicatissima*. Some palæontologists consider them to be distinct species, others varieties, and some merge them into one.

If we examine Quenstedt's figures of both forms in pl. 26 of the 'Handbuch,' and pl. 17 of 'Der Jura,' we find that almost all our British examples agree entirely in shape and character with Quenstedt's figures of *T. calcicosta;* and indeed they seem as if drawn from some of our Churchdown or Stonehouse specimens. *Rh. plicatissima*, Quenstedt, as its name implies and Quenstedt's figures show, is a shell with many more and smaller ribs. I have two German specimens of the last-named form, sent me by Dr. Oppel, from Ginünd and Ofterdingen, which show a larger number of smaller ribs than is seen in the English and Scotch examples of *R. calcicosta.* Indeed, I do not positively know any British specimens that could be correctly identified with the German *Rh. plicatissima*, and therefore think it will be more correct to refer the shells under description to *Rh. calcicosta.*

I cannot agree with Prof. Tate or Dr. Brauns in uniting several species with smooth umbonal regions, such as *Rh. gryphitica*, *Rh. oxynoti*, and others, with the essentially ribbed *Rh. calcicosta.* Dr. D. Brauns states in his 'Nordwestlicher Deutschland' that *Rh. curviceps* (Quenstedt), 'Jura,' pl. 17, figs. 13—15, and *Rh. tetrahedra rufimontana*, pl. 37, figs. 1, 2, 3, 1870, are synonyms of the species under description; but, as I have not seen authentic German types, I will not venture upon any opinion on that subject.

Localities.—Specimens of *Rh. calcicosta* have been found by the Rev. F. Smithe, Prof. Tate, and others in the zone of *Am. margaritatus*, at Huntcliff in Yorkshire,—in the top bed of the *Am. Bucklandi* zone, of the Lower Lias, of Churchdown, Gloucestershire,—at Stonehouse and Badgsworth near Cheltenham, and also at Applecross in the West of Scotland, &c. The shell is exceedingly abundant in some of our Lower Lias localities.

230. Rhynchonella Glevensis, *Smithe*, MS. Dav., Sup., Pl. XXVIII, fig. 22.

Shell somewhat triangular, longer than wide, broad anteriorly, corners rounded, straight in front, tapering posteriorly into an acute, incurved beak; valves almost equally convex or deep. Dorsal valve divided into three lobes, of which the central one forms a moderately raised and broad mesial fold, a shallow sinus corresponding to it in the ventral valve. Surface of each valve ornamented with about sixteen simple, angular, radiating ribs, of which about four occupy the fold, and three the sinus.

Length 6, width $5\frac{1}{2}$, depth 4 lines.

Obs.—This small species is distinguishable from *Rh. plicatissima* by its greater length as compared with its width. Several specimens of this shell were discovered by the Rev. F. Smithe in the *Am. angulatus* zone, and are especially interesting as occurring so early in the Lias,—the only Hettangian species, according to the Rev. F. Smithe, taking that word to comprise the *Am. planorbis* and *Am. angulatus* beds. Indeed, scarcely

any *Rhynchonellæ* are cited in the works of foreign palæontologists as having been found in rocks of that period. The Rev. F. Smithe has proposed for the species under description the name of *Glevensis*, from Glevum, the ancient name of Gloucester.

231. Rhynchonella capitulata, *Tate*. Dav., Sup., Pl. XXVII, figs. 11, 12.

Rhynchonella capitulata, *Tate*. The Yorkshire Lias, p. 424, pl. xv, fig. 24, 1876.

"Shell ovato-triangular, slightly transverse, with an elevated angular mesial fold; anterior third of the shell plaited, two to four (usually three) plaits on the mesial fold, and about five on each lateral area; the umbones gibbous; from the appearance which the gibbosity presents the shell has been named *Capitulata*. Beak thick, small, suberect. The shell never attains any considerable size."

The dimensions of the largest specimens are—breadth $\frac{11}{20}$ inch, height $\frac{8}{20}$ inch, thickness $\frac{7}{20}$ inch.

Geological positions.—Middle Lias (Zone of *Am. spinatus*), main seam, where it is very abundant, Eston, Challoner, Upleatham, and Hob Hill mines, Yorkshire (Tate).

232. Rhynchonella spinosa, *Schloth*. Dav., Ool. Mon., p. 71, Pl. XV, figs. 15—20.

Rhynchonella spinosa is very variable in shape, and in the number of its spinulous ribs, but I cannot agree with M. Koechlin-Schlumberger's statement (in vol. xiv, 2nd ser., p. 166, of the 'Bulletin of the Geological Society of France' for 1856), that this shell and *Rh. senticosa* should be considered one and the same species; but I entirely concur with him when he observes that he is against the system of restricting a species to a certain bed or horizon, and giving it a new name should it be subsequently discovered in a higher or lower horizon. But, at the same time, the error must be carefully avoided of supposing that when allied forms occur on the *same horizon* they must therefore be only varieties of the same species. *Rh. spinosa* occurs in great profusion in the Inferior Oolite at Bradford Abbas, Crewkerne Station, and several other places both in Dorset and Somersetshire. It has also been found by Mr. J. F. Walker in the Fullers' Earth of Powerstock, near Bridport.

233. Var. *Bradfordiensis*, Walker MS. Sup., Pl. XXVII, figs. 18, 19.

This appears to be a small variety of *Rh. spinosa*, resembling the young of *Rh. concinna*.

This shell, which is covered with spines, was found by Mr. J. F. Walker in the Bradford Clay of Tetbury Road, near Cirencester ('Proceedings of the Yorkshire Naturalists' Club,' p. 214, 1869, and 'Geol. Mag.,' 1870). It has also been found by Prof. Seeley in the Bradford Clay of Bradford, Wiltshire.

234. Rhynchonella Crossi, *Walker*, Sup., Pl. XXVII, fig. 17.

Rhynchonella Crossi, *Walker*. Proceedings of the Yorkshire Naturalist Club, p. 214, 1869; and Geol. Mag., vol. vii, p. 562, 1870.

Shell small, wider than long, or somewhat transversely oval. Dorsal valve rather deeper and more convex than the opposite one, and ornamented with from thirteen to fifteen strong radiating ribs of which three or four form a slightly raised mesial fold. Ventral valve divided by a moderately deep sinus, occupied by two or three longitudinal ribs, with six or seven on each of the lateral portions of the valve. A variable number of spines rise at unequal intervals from the upper edge of each rib. The valves are closely and concentrically striated. Beak small, foramen concealed under its incurved extremity.

Length 4, width 5, depth 3 lines.

Obs.—This species can be distinguished from *Rh. spinosa* by its small dimensions, and few strong ribs. It was discovered by the Rev. E. Cross in the Inferior Oolite (Lincolnshire Limestone) of Appleby, near Brigg, Lincolnshire, and subsequently by Mr. J. F. Walker in the same formation at Brough, near Hull, in Yorkshire. Mr. S. Sharp has also mentioned having found it in the shelly beds of Ponton, in his paper on the Oolites of Northamptonshire, published in the 'Quarterly Journal of the Geological Society,' vol. xxix, p. 265, 1873. It is stated by Professor Judd to occur in several localities; see his valuable Memoir on the "Geology of Rutlandshire," 'Geological Survey,' 1875.

235. Rhynchonella senticosa, *Von Buch*. Dav., Ool. Mon., p. 73, Pl. XV, fig. 21.

Nothing new. It occurs in the Inferior Oolite at Bradford Abbas, Crewkerne Station, and in some other places in Dorset and Somersetshire, where it is rare.

236. Rhynchonella jurensis, *Quenstedt*. Sup., Pl. XXVII, figs. 24 to 27.

Terebratula jurensis, *Quenstedt*. Die Jura, p. 287, tab. xli, figs. 33, 34, 35, 1858.

Professor R. Tate in his paper on new Secondary Brachiopoda published in the 'Geol. Mag.' for December, 1869, quotes this species from the Zone of *Am. opalinus* (Upper Lias) of Great Britain, but does not give the locality. He states that "Mr. Lycett ('Proc. Cotts. Club,' vol. ii, p. 142, 1860) records the above species from the upper zone of the Supra-Liassic Sands." I have seen the specimen in the Lycett collection purchased by the School of Mines of London, and have no hesitation in stating that it is referable to *Rh. rimosa* of Von Buch. But now comes the question, What is *Rh. jurensis?* If we refer to pl. xli of 'Die Jura,' we find that Professor Quenstedt gives figures of his so-termed species, which are apparently referable to at least two, if not three, distinct shells. Taking the first-named figure (33) *as the type*, we have a small subpentagonal shell, five lines in length by six in breadth, and three and a half in depth; the valves are almost equally convex or deep; the surface of each valve is ornamented with about twelve strong, simple, radiating ribs, of which four compose a wide, well-defined, and moderately elevated mesial fold; beak pointed, incurved; sinus in ventral valve shallow. Fig. 34 is about similarly shaped, but the surface of each valve has about twenty small simple ribs. With regard to fig. 35, Quenstedt states, at p. 287 of the work above quoted, that the specimen has its ribs divided like *rimosa*. It is, however, *Rh. rimosa* and cannot be classed with fig. 34, which evidently belongs to another species. Feeling that *Rh. jurensis*, as described by Quenstedt, was a very uncertain species, I wrote to Dr. Fraas upon the subject, and he, in the kindest possible manner, at once forwarded me a specimen as a type. This, although possessing more ribs, most nearly approached fig. 33 in shape.

Taking Quenstedt's fig. 33 as the type of his *Rh. jurensis*, we find a similarly shaped shell associated with *Wald. Lycetti* in several localities in the neighbourhood of Banbury, and especially at the Bloxham cutting on the Banbury and Cheltenham Railway, and always in the Zone of *Am. communis* or Upper Lias. Our English specimens do not seem to have much exceeded six lines in length, by about the same in breadth, and three in depth.

It is not a rare fossil in the locality above named. From three to six ribs occupy the fold, and these are generally more strongly marked on the anterior half of the shell.

237. Rhynchonella Deslongchampsii, *Dav.*

Mr. Charles Moore states in the 'Proc. of the Somersetshire Archæological and Nat.

Hist. Soc.,' vol. xiii, p. 41, 1865–6, to have found this species in the Middle Lias of Whatley, near Frome, but, as the specimen has been mislaid, I can refer only to the statement above given, and cannot affirm its existence as a British fossil. *Rh. Deslongchampsii* is a fine large shell, and was first described and figured by myself from a specimen obtained in 1852 from the Lias of Fontaine-Etoupe-Four, near Caen, in Normandy. It was subsequently redescribed and figured by M. E. Deslongchamps in vol. ii of the 'Bulletin of the Linn. Soc. of Normandy,' 1857.

238. Rhynchonella fallax, *E. Deslongchamps.*

Mr. Charles Moore states that he found this species in the "abnormal" Lias (Middle Lias) at Whatley ('Quarterly Journal Geol. Soc.,' vol. xxiii, pp. 480 and 560, 1867. I regret that Mr. Moore could not find this specimen in his collection, so that all I can do is to quote the statement he made in his paper "On Abnormal Secondary Fossils."

239. Rhynchonella Morierei, *Dav.* Ool. Mon., p. 92, Pl. XVIII, figs. 12, 13.

Nothing new. Cornbrash.

Mr. J. F. Walker informs me that he has recently seen examples of *Rh. tetrahedra*, var. *curviceps*, Quenstedt, or *Rh. tetrahedra*, β, 'Hand. Petref.,' pl. xxxvi, fig. 30, in the collection of Mr. Innes Griffin, who had found them in the Middle Lias at Fenny Compton, near Banbury. It occurs in Germany in Lias γ, corresponding to *Am. Jamesoni* zone in England.

240. Lingula Brodiei, *Dav.* Sup., Pl. IX, fig. 31.

[The reader is requested to erase the last two lines of p. 76 and the first seven lines of p. 77 of this Supplement, and to replace them by the following.]

In external shape *Lingula Brodiei* is elongated, with almost straight and parallel sides, tapering beak, and rounded front; surface smooth.

Length 6, width $2\frac{1}{2}$ lines.

Obs.—A single incomplete valve of this *Lingula* was found by the Rev. P. B. Brodie in the Coral Rag of Wheatley, Oxon. It seems distinguishable from *L. ovalis* by its almost straight sides and very acuminated beak. I gave a sketch of it in Pl. IX, fig. 31, and now feel much pleasure in naming it after its distinguished discoverer. It is the only specimen of the genus at present known from the Coral Rag of Great Britain, and it is interesting, because species of Brachiopoda are few in this formation. Wheatley is an important geological locality, situated about five miles east of Oxford (as the crow

flies), and beyond the eastern slope of Shotover. Mr. James Parker, of Oxford, informs me—"There are two large quarries still open at Wheatley, the stone there being practically a free stone, and used largely for building. In the Bursar's Rolls of Merton College, when they were building a new kitchen A.D. 1278, we read 'Idem comput. iiij.s. liberatos Nicholai Pret. pro viii. Magnis francis lapidibus, qui vocantur sules (*i. e.* Sills or fr. Seuils), emptis apud Watele.' But the stone does not stand the town atmosphere."

Lingula Brodiei is quite distinct from another elongated *Lingula*, of about the same size (Sup., Pl. XXIX, fig. 22), likewise found by the Rev. P. B. Brodie in the Concretionary Junction Bed at Ringstead Bay, near Weymouth, between the Coral Rag and Kimmeridge Clay, and alluded to at p. 43 of the 'Proceedings of the Warwickshire Naturalists' and Archæological Field Club,' 1874.[1] In pp. 76 and 77 of this Supplement, I confused *two Linguloe*, which are situated in widely separated localities, and perhaps distinct geological horizons. Mr. Brodie's specimen is too incomplete to admit of a positive identification.

241. Crania Griffini, *Dav.*[2] Sup., Pl. XXIX, fig. 23.

An upper or unattached valve only of this species has been found by Mr. Innes

[1] "On Thursday some of the members drove to Ringstead Bay, commencing with the coast section of Coral Rag on the West, and thence to Ringstead, where a fine section of the clay, full of fossils, is exposed, capped by the Purbeck, and further on to the East is succeeded by the Lower Chalk and Greensand. A peculiar band called Kimmeridge Grit was noticed between the Coral Rag on the West and Ringstead; it is said to contain fossils of the Coral Rag and Kimmeridge Clay, the latter, however, appearing to predominate; and the Rev. P. Brodie found a *Thecosmilia*, of which several specimens were obtained, which differs from common species (*T. annularis*) of the Coral Rag, and does not seem to have been noticed here before. The following section and fossils were determined:

"1. Clay, with layers of *Ostrea deltoidea, Rhynchonella inconstans,* and *Gryphæa virgula.*

"2. Stone sand with Corals (*Thecosmilia,* sp.?). *Lingula* very elongated (not *ovalis*), *Serpula intestinalis, Trigonia clavellata, Lima pectiniformis, Pholadomya angustata, Phasianella striata, Lima, Thracia, Gervillia,* and *Cucullæa.*

"3. Clay full of *Ostrea deltoidea, Gryphæa virgula, Serpula intestinalis, Rhynchonella inconstans.* Dip to the East.

"No. 2 is said in Damon's 'Guide to Geology of Weymouth' to be the concretionary junction bed, a few inches thick between Kimmeridge Clay and Coral Rag; in this the Corals occur, and it is overlain by a stratum of clay charged with the characteristic fossils of the Kimmeridge Clay; and No. 3 below contains similar fossils. The intervening stony band must belong to the Kimmeridge Clay, and as far as could be observed all the other associated organisms are well-known Kimmeridge Clay species, and, if so, this is the first time any Coral has been found in it."

[2] This species has been referred to by the Rev. F. Smithe, F.G.S., in his admirable memoir on the 'Middle Lias of North Gloucestershire,' in which paper the *Ammonites spinatus* zone is particularly described. Mr. Smithe states that Brachiopoda of the Tretenterate division are scarcely to be expected in the *Spinatus* sands.

Griffin in the zone of *Am. spinatus*, Middle Lias of King's Sutton, near Banbury. It is an oblong square, wider than long, pyramidal, with four flattened planes converging to a pointed, nearly central vertex. The posterior margin is the broadest part of the shell, and presents a slight inward curve. The lateral margins are nearly straight, and the frontal edge gently convex. Surface smooth, feebly marked at intervals with a few concentric lines of growth.

Length 4, width 5 lines.

The internal surface of the valve is partly obscured by the matrix, but the two submarginal, large, muscular scars are clearly observable, separated by a small concave space.

Obs.—It is not possible, from the inspection of the external surface of a single valve, to be able to point out its real characters and affinities. This shell bears most resemblance to *C. Gumberti*, E. Desl. ('Bull. Soc. Linn. de Normandie,' vol. vii, pl. iii, figs. 6—9, 1862), from the Middle Lias of May, Calvados, France, but *C. Griffini* is a smaller shell, as far as we know, and is less rugose. It is also smoother than *C. Gumberti*, more regular in shape, and more oblong, the French species being almost square.

King's Sutton, in Northamptonshire, is a very interesting locality, which has afforded to Messrs. Beesley, Griffin, and Walford many species of Brachiopoda and other fossils. It is there that so many fine examples of *Spiriferina oxygona* have been collected. *Sp. rostrata* occurs there likewise, *Ter. punctata*, *T. Edwardsi*, *Wald. resupinata*, *Rh. acuta*, *Rh. tetraëdra*, *Rh. amalthei*, *Rh. fodinalis*, and two or three other species of the last-named genus.

242. Spiriferina adscendens, *E. Desl.* Dav., Sup., Pl. XXIX, fig. 20.

Spirifer rostratus, *Dav.* (A malformation.) Annals and Mag. Nat. Hist., 2nd ser., vol. ix, pl. xv, fig. 11, 1852.

Spiriferina adscendens, *E. Desl.* Bull. Soc. Linn. de Normandie, vol. iii, p. 165, pl. iv, figs. 7—9, 1858.

Shell generally irregular and unsymmetrieal, about as long as wide. Dorsal valve semicircular, very convex and small when compared to the ventral one; mesial fold rounded, not much defined, and gradually blending with the lateral lobes of the valve. Ventral valve irregular, more or less contorted, very large, somewhat pyramidal, and more or less bent backwards at an obtuse or even right angle to the plane of the dorsal valve. Area triangular, very large, flat, and divided in the middle by a long, narrow, elongated, triangular fissure. A deepened sinus extends likewise from near the extremity of the beak to the front. External surface of valves strongly punctated.

Length 14, breadth 11, depth 10 lines.

Obs.—In 1852 I provisionally described a French example of this fossil as a malformation of *Sp. rostratus*, but subsequently M. E. Deslongchamps, having discovered that the shell occurred in the Middle Lias of Fontaine-Etoupe-Four in Normandy, and always with the same shape and characters, described it under the name of *adscendens*.

During a visit to the Bridport Institution Mr. C. Moore noticed the fine example figured in our plate, which is stated to have come from the Middle Lias near Chideock. As it is the only British example with which I am acquainted, a search for others in the same locality would be desirable. A fine specimen of *Thecidium Moorei* is attached to one of its valves.

243. Spiriferina Tessoni, var.?, *Dav.* Sup., Pl. XXIX, fig. 21.

Spiriferina Tessoni, *Dav.* Annals and Mag. Nat. Hist., vol. ix, 2nd ser., pl. xv, figs. 1, 2, 1852.

Shell transversely semicircular, wider than long; hinge-line straight, not quite as long as the greatest breadth of shell; cardinal angles rounded. Dorsal valve convex, and divided into three portions, the central one forming a moderately elevated and sharply defined, rounded mesial fold. Ventral valve much deeper than the opposite one; area large, nearly flat, and triangular, and sloping back at an almost right or obtuse angle with the plane of the dorsal valve, and divided by a triangular fissure; the beak much produced, and bent upwards near its extremity. Surface of both valves ornamented by a variable number of small angular plaits or ribs, from thirty to thirty-five in number, of which more than half are due to bifurcation or intercalation at variable distances from the beak and umbone. From the ribs, at intervals, rise short vertical spines, in addition to the minute perforations which traverse the shell.

Length 11, width 14, depth 11 lines.

Obs.—Some French examples of this fine species have attained, and even exceeded, $22\frac{1}{2}$ lines in length, by 35 in width, and 16 in depth. The species was first found in the Middle Lias of Fontaine-Etoupe-Four in Normandy by Messrs. Tesson and E. Deslongchamps.

During a recent visit to the Museum of the Bridport Institution Mr. C. Moore observed a specimen of this species stated to have been obtained from the Middle Lias of Chideock, and kindly borrowed the specimen that I might figure and add it to my Monograph of British Oolitic and Liassic Brachiopoda.

CONCLUDING REMARKS.

After three years of uninterrupted research devoted to the elaboration of this Jurassic and Triassic Supplement, I have felt more and more the great difficulty in dealing with species and their interminable variations. Certainly it saves much trouble to unite under a single name, as some palæontologists have done, a great many so termed species, which other palæontologists have considered to be distinct, but these combinations, often judicious, have in many cases been the result of much guesswork, and not of positive study, and thus, instead of clearing away confusion, have materially added to it. It is decidedly wrong to burden the classification with an unnecessary number of specific names for a thing that should have but one. The difficulty often is where to draw the line.

In this Supplement about 209 so-termed species and 30 named varieties have been described and illustrated, namely, 1 species from the Rhætic formation, 87 species with 6 named varieties from the Lias, and 127 species with 24 named varieties from the Oolites, 6 species being common to the Lias and the Oolites, but I feel convinced that some years hence, when the subject shall have been still more studied than it has been up to the present time, and with a still larger command of material, this number will require to be largely reduced, for some of the so-termed species that swell up the number are based on minute objects which may turn out to be the young of other species, and some forms that are at present supposed to be distinct, will prove to be mere variations in shape or varieties. Noting, therefore, these serious imperfections, which I fear must inevitably accompany similar Monographs, I believe, nevertheless, that the large bulk of the species described in this Supplement are good, as far as species go, as they have been elaborated with the greatest possible care and attention. It has several times been deemed preferable to give a provisional name to an uncertain form, rather than to incorporate it with a good, well-defined species to which I did not feel certain it belonged.

The important and zealous help I have received, during the preparation of this Supplement, from Messrs. J. F. Walker, C. Moore, F. Smithe, Buckman, Darell Stephens, J. Prestwich, J. Parker, R. Etheridge, R. Tate, J. F. Blake, W. H. Hudleston, T. Beesley, P. B. Brodie, J. W. Judd, J. Griffin, E. A. Walford, and others, sufficiently attests the efforts that have been made to place before the Members of the Palæontographical Society as complete a Monograph as the material at our command could enable us to produce. I would, however, urgently recommend a further and continued study of the subject, and a search for more specimens of those forms that are still insufficiently elaborated, by those who may be favourably located for similar investigations.

If we briefly scan the results obtained as to the *approximate* number of species and

named varieties found in each of the British divisions of the Jurassic system we find as follows:

THE LIAS.

In the *Lower Lias* about 23 species and 1 named variety.
„ *Middle Lias* „ 60 „ „ 5 or 6 varieties.
„ *Upper Lias* „ 29 „ „ 1 or 2 „

Of these, nineteen to twenty are common to two or three of these great divisions of the Lias, while four or five only have been hitherto shown as positively passing from the Lias into the Oolites. It is, however, probable that, when better known, a larger number may be discovered. It was during the deposition of the Middle Lias that the Brachiopoda were both specifically and individually most numerous. The Liassic deposits have been divided by different geologists and palæontologists into a certain number of Zones characterised by certain species of Ammonites. Mr. R. Tate in 1869, in the 'Geological Magazine,' vol. vi, 1869, distributed the British Liassic Brachiopoda, that were known to him at the time, into Zones to which we have already referred. This mode of proceeding, as a matter of detail, is of great importance, and it should be proceeded with for the species in those localities where the sequence of zones is fairly represented. As an example of what can be done in this direction by local geologists, I have appended a table prepared with great care, at my request, by the Rev. F. Smithe, in which he has noted the range and distribution of each Liassic species in the zones so well represented in the Lias of Churchdown, in Gloucestershire, and I have myself verified his and my own identification.

Species of Brachiopoda found by the Rev. F. SMITHE *in the Lias of Churchdown and its neighbourhood.*

ZONES.	Am. planorbis.	Am. angulatus.	Am. Bucklandi.	Am. Turneri.	Am. obtusus.	Am. oxynotus.	Am. raricostatus.	Am. Jamesoni.	Am. ibex.	Am. capricornus.	Am. margaritatus.	Am. spinatus.	Am. communis.	Am. Jurensis.	Am. opalinus.	Passing on to Oolitic strata.
(TRETENTERATA)—																
Lingula Metensis, *Terquem*	...	...	...	×	×											
Discina Holdeni, *Tate*	...	...	...	...	...	...	...	×	×							
(CLISTENTERATA)—																
Terebratula punctata, *Sow.*	...	...	...	...	...	...	...	...	×	×	×	×	...	×		
„ Haverfieldensis, *Davids*	...	...	...	...	...	...	...	...	...	...	...	...	...	×		
„ Radstockensis, *Davids.*	...	...	...	...	...	...	...	...	×							
„ Edwardsi, *Davids*	...	...	...	...	...	...	...	...	...	...	×	×				
„ globulina, *Davids.*	...	...	...	...	...	...	...	...	...	...	...	×	×			
Waldheimia perforata, *Piette.*	...	×	...	...	...	×	...	...	×	...	...	×				
„ indentata, *Sow*	...	...	...	...	...	...	...	...	...	...	...	×				
„ quadrifida, *Lamk*	...	...	...	...	...	...	...	...	...	...	×	×				

Zones.	Am planorbis.	Am. angulatus.	Am. Bucklandi.	Am. Turneri.	Am. obtusus.	Am. oxynotus.	Am. raricostatus.	Am. Jamesonii.	Am. ibex.	Am. capricornus.	Am. margaritatus.	Am. spinatus.	Am. communis.	Am. jurensis.	Am. opalinus.	Passing on to Oolitic Strata.
Waldheimia cornuta, *Sow.*	...	...	...	...	...	...	...	...	...	×	×	×				
„ numismalis, *Lamk.*	...	...	...	...	...	...	...	×	×	...	×	×	×			
„ subnumismalis, *Davids.*	...	...	...	...	...	...	...	...	...	...	×	×				
„ Mariæ, *d'Orb.*	...	...	...	...	...	...	...	...	...	...	...	×				
„ Lycetti, *Davids.*	...	...	...	...	...	...	...	...	...	...	...	...	×			
„ resupinata, *Sow.*	...	...	...	...	...	...	...	...	...	...	×	×				
Rhynchonella tetraëdra, *Sow.*	...	...	...	...	...	...	...	...	...	×	×	×				
„ rimosa, *Buch.*	...	...	...	...	...	...	...	×	×	×	...	×				
„ calcicosta, *Quenst.*	...	×	×	×	×	×	×									
„ amalthei, *W. S.*	...	...	...	...	...	...	...	...	...	...	×	×				
„ acuta, *Sow.*	...	...	...	...	...	...	...	...	...	...	×	×				
„ cynocephala, *Richard*	...	...	...	...	...	...	...	...	...	...	...	×	...	×		
„ pygmæa, *Morris*	...	...	...	...	...	...	...	...	...	...	...	...	×			
„ variabilis, *Schloth.*	...	...	...	...	...	×	...	×	×	×	×	×				
„ Glevensis, *Smithe*	...	×														
„ oxynoti, *Quenst.*	...	...	...	...	...	×										
Spiriferina Muensteri, *Davids.*	...	...	...	...	...	...	...	...	...	...	...	...	×			
„ Walcotti, *Sow.*	...	...	...	...	...	×	...	...	...	...	...	×				
„ rostrata, *Schloth.*	...	...	...	...	...	...	...	...	×	...	×	×				
„ verrucosa, *Buch.*	...	...	...	...	...	...	...	×								
„ Ilminsteriensis, *Davids.*	...	...	...	...	...	...	...	...	...	...	...	...	×			
Leptæna liasina, *Bouchard.*	...	...	...	...	...	...	...	...	...	...	...	...	×			
„ Moorei, *Davids.*	...	...	...	...	...	...	...	...	...	...	...	...	×			

If we view the Lias as a whole, it will be found that not more than from 70 to 75, if so many, good species have, up to the present time, been discovered in that formation in Great Britain.

The Oolites.

We begin the Oolitic Series by those so termed "Passage-beds," or "Midford Sands," classed by some geologists as part of the Upper Lias, and by others as the base of the Oolite Series.

1. *Passage-beds.*—6 species and 2 varieties have been recorded; but I would invite a further search and a more complete study of the species that occur in this important deposit.

2. *Inferior Oolite.*—67 species and a few named varieties; but this list has been somewhat increased by several minute forms which in some cases may turn out to be the fry or young of some of the others, so that we must estimate at under 60 the number of good species discovered in this, the richest of the formations composing the Oolitic Series.

3. *Fullers' Earth-rock.*—Some 6 or 7 species. Of these at least six occur likewise in the Inferior Oolite, showing the close connection between the two formations.

4. *Great Oolite and Stonesfield Slate.*—Some 17 species. Of these, one or two only seem to have lived during the formation of the Inferior Oolite and Fullers' Earth.

5. *Forest Marble and Bradford Clay.*—About 11 species, of which 8 are found also in the Great Oolite, and, indeed, these last two small and local divisions should be considered (as is usual) to constitute a part of the Great Oolite formation.

6. *Cornbrash.*—About 12 species and 4 named varieties.

7. *Kelloway rock.*—3 or 4 species.

8. *Oxford Clay.*—5 or 6 species.

9. *Lower Calcareous Grit.*—5 or 6 species.

10. *Coralline Limestone.*—10 or 11 species.

11. *Supra-coralline.*—About 7 species.

12. *Kimmeridge Clay.*—6 species.

13. *Portland.*—1 uncertain fragment of a *Rhynchonella.*

14. *Purbeck.*—None.

Thus, it appears that some 127 species and 24 named varieties have been distributed through the sequence of Oolite deposits; but, as several of the species are still uncertain, and some may be only the young of others, not many more than 100 well-made-out species can at present be put down to our Oolites; and, if we add to this number some 70 from the Lias, about 170 species will have been correctly established as occurring in our British Jurassic deposits. The Inferior Oolite has furnished by far the largest number, both as regards species and individuals; and subsequent to that period a very great, notable, and almost sudden diminution is observable in the Oolitic Strata that followed it. It is also from the Inferior Oolite that the largest species have been collected.

With regard to the *Coral Rag*, I may here reproduce a few passages taken from Messrs. T. F. Blake and W. H. Hudleston's admirable Memoir on the Corallian Rocks of England, published in vol. xxxiii of the 'Quarterly Journal of the Geological Society,' 1877. "The descriptions we have given of the actual development of Corallian Rocks in England shows how inappropriate is the term 'Coral Rag' as a designation for the whole, anything that could be lithologically called by that name forming but a very small part of the series. 'Coralline Oolite' is an equally inappropriate term when separated from the rock which it properly describes." The Corallian deposits are regarded by Messrs. Blake and Hudleston as being represented, when complete, by the following series, in ascending order:

1. *The Lower Calcareous Grit.* 2. *The Lower Limestone or Hambleton Oolite.* 3. *The Middle Calcareous Grit.* 4. *The Coralline Oolite.* 5. *The Coral Rag.* 6. *The Supra-coralline beds.*

We have, however, in our Table reduced these six divisions to three in number.

INDEX AND TABLE SHOWING THE DISTRIBUTION OF BRITISH TRIASSIC, LIASSIC AND OOLITIC BRACHIOPODA.

Supplement page.	Genus, Species, and Reference to Plates.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Passage Beds, Midford Sands.	Inferior Oolite.	Fuller's Earth.	Great Oolite, Stonesfield Slate.	Forest Marble and Bradford Clay.	Cornbrash.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit Passage Beds.	Coralline Limestone.	Supra-Coralline.	Kimmeridge Clay.	Portland.	Purbeck.
74	Lingula ovalis, *Sow.* Dav. Ool. Mon., p. 98, pl. xviii, fig. 14; Sup., pl. ix, figs. 1—9; pl. x, fig. 16 *b*; pl. xi, fig. 29; pl. xxix, fig. 22 (?)																		
75	— Craneæ, *Dav.* Sup., pl. ix, figs. 21, 22												×				×		
75	— longo-viciensis, *Terquem.* Dav., Sup., pl. ix, figs. 24, 25, 26			×	×														
76	— Davidsoni, *Oppel.* Sup., pl. ix, figs. 23, 23 *a*		×																
77	— Metensis, *Terquem.* Sup., pl. ix, figs. 27—30		×																
225	— Brodiei, *Dav.* (Coral Rag, Wheatly, Oxon) Sup., pl. ix, fig. 31													×					
78	— Beanii, *Phillips.* Ool. Mon., p. 9 (in part, not figures); Sup., pl. ix, figs. 9, 10, 11, 12					×													
79	— sacculus, *Dewalque.* Ool. Mon. (pars), pl. i, figs. 1, 1 *a*, *b*, *c*, *d*; and Sup., pl. ix, figs. 15—20; and pl. x, fig. 25			×															
80	Discina latissima, *Sow.* Dav. Sup., pl. x, figs. 16—19; and pl. xi, fig. 30																×		
81	— elevata, *Blake.* Sup., pl. xi, fig. 31																×		
81	— Humphresiana, *Sow.* Dav. Ool. Mon., p. 10, pl. i, figs. 3, 3 *a*, *b*; and Sup., pl. xiii, figs. 17—19																×		
82	— reflexa, *Sow.* Ool. Mon., p. 10, pl. x, fig. 8; and Sup., pl. x, figs. 1—6				×	×													
83	— orbicularis, *Moore.* Sup., pl. x, figs. 9, 9 *a*, *b*, 10				×														
84	— Davidsoni, *Moore.* Sup., pl. x, figs. 11, 11 *a*		×																
84	— Dundriensis, *Moore.* Sup., pl. x, figs. 13, 13 *a*						×												
85	(?) Moorei, *Dav.* Sup., pl. x, figs. 14, 14 *a*				×														
85	— Holdeni, *Tate.* Dav. Sup., pl. x, figs. 12, 12 *a* (7, 8 ?); and pl. xi, fig. 32		×	×															
86	— Etheridgei, *Dav.* Sup., pl. x, figs. 20, 20 *a*, *b*						×												
87	(?) annulosa, *Dav.* Sup., pl. x, figs. 15, 15 *a*, *b*										×								
87	— Babeana, *d'Orb.* = Townshendi, *Forbes.* Dav. Ool. Mon., p. 9, pl. i, figs. 2 *a*, *b*; and Sup., pl. x, figs. 21—24	×																	
89	Crania Moorei, *Dav.* Ool. Mon., p. 12, pl. i, fig. 9				×														
89	— antiquior, *Jelly.* Dav. Ool. Mon., p. 11, pl. i, figs. 4—8; and Sup., pl. ix, figs. 36, 37								×										
89	— Saundersii, *Moore.* Sup., pl. ix, figs. 38—39						×												
90	— canalis, *Moore.* Sup., pl. ix, figs. 32—35						×												
90	— Gumberti, *E. Desl.* Sup., pl. ix, figs, 40, 40 *a*, *b*, 41, 41 *a*			×															
91	— liassica, *Moore.* Quarterly Journ. Geol. Soc., vol. xxiii, p. 539, 1867		×																
226	— Griffini, *Dav.* Sup., pl. xxix, fig. 23			×															

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91	Leptæna Davidsoni, *E. Desl.* Sup., pl. x, figs. 27—30			×	×														
92	— Bouchardi, *E. Desl.* Dav. Ool. Mon., p. 19, pl. i, fig. 22			×															
92	— rostrata, *E. Desl.* Sup., pl. x, figs. 30, 30 *a*, *b*			×															
93	— liasiana, *Bouchard.* Dav. Ool. Mon., p. 18, pl. i, fig. 21				×														
93	— Moorei, *Dav.* Ool. Mon. p. 17, pl. i, fig. 18				×														
93	(?) Pearcei, *Dav.* Ool. Mon., p. 17, pl. i, fig. 19 (not a Brachiopod; referable to genus *Monotis*)																		
94	(?) granulosa, *Dav.* Ool. Mon., p. 18, pl. i, fig. 20 (see *Terebratulina ? Deslongchampsii*)																		
95	Spiriferina rostrata, *Schlotheim.* Dav. (pars) Ool. Mon., p. 20, pl. ii, figs. 1—6, 13—21 (not figs. 7—12, or pl. iii, fig. 1); Sup., pl. ix, fig. 6		×	×	×														
95	— Hartmanni, *Zieten.* Dav. Ool. Mon., p. 22, pl. ii, figs. 10—12; and Sup., pl. xi, fig. 7			×															
96	— pinguis, *Zieten* (not *Sow.*). Dav. Ool. Mon., p. 20, pl. ii, figs. 7—9; Sup., pl. xi, fig. 8		×	×															
97	— verrucosa, *von Buch.* Dav. Ool. Mon. (pars), p. 20, pl. iii, fig. 1; Sup., pl. xi, figs. 9, 10			×															
98	— Walcotti, *Sow.* Dav. Ool. Mon., p. 25, pl. iii, figs. 2, 3		×	×															
99	— oxyptera, *Buvignier.* Sup., pl. x, figs. 31, 32			×															
99	— Signiensis, *Buv.* (?) Sup., pl. xi, fig. 11		×																
100	— oxygona, *E. Desl.* Sup., pl. xi, figs. 1—5			×															
101	— Münsteri, *Dav.* Ool. Mon., p. 26, pl. iii, figs. 4—6			×	×														
101	— Deslongchampsii, *Dav.* Sup., pl. xi, fig. 12			×															
101	— Ilminsteriensis, *Dav.* Ool. Mon., p. 24, pl. iii, figs. 7, 7 *a*				×														
227	— adscendens, *E. Desl.* Dav. Sup., pl. xxix, figs. 20, 20 *a*			×															
228	— Tessoni, var. ? *Dav.* Sup., pl. xxix, figs. 21, 21 *a*, *b*			×															
102	(?) oolitica, *Moore.* Dav. Supplementary Appendix, vol. i, p. 30; and Sup., pl. xi, figs. 13—15						×												
103	(?) minima, *Moore.* Dav. Sup., pl. xi, fig. 17						×												
103	(?) Moorei, *Dav.* Sup., pl. xiii, fig. 20				×														
104	Thecidium ornatum, *Moore.* Sup., pl. xiii, figs. 5—9														×				
105	(?) pygmæum, *Moore.* Sup., pl. xiii, figs. 16, 16 *a*, *b*, *c*														×				
105	— Moorei, *Dav.* Ool. Mon., p. 13, pl. i, fig. 10		×	×	×														
106	— Bouchardii, *Dav.* Ool. Mon., p. 14, pl. i, figs. 15, 16; Sup., pl. xiii, figs. 1, 2, 3			×	×		×												
106	— Dickensoni, *Moore.* Ool Mon., p. 14, pl. xiii, fig. 19						×												
106	— triangulare, *d'Orb.* Dav. Ool. Mon., p. 14, pl. i, figs. 11, 12; and Sup., pl. xii, figs. 25, 26		×	×	×		×	×	×						× ?				
107	— rusticum, *Moore.* Dav. Ool. Mon., p. 15, pl. i, fig. 14; and Sup., pl. xiii, fig. 10 ?		×	×	×														
107	— sub-serratum, *R. Tate.* Sup., pl. xiii, figs, 11, 12, 13		×																
108	— Deslongchampsii, *Dav.* Appendix to vol. i, p. 14, pl. A, figs. 6, 6 *a*			×															
108	— duplicatum, *Moore.* Dav. Supplementary Appendix to vol. i, p. 30; Sup., pl. xii, figs. 15—20						×												

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108	Thecidium serratum, *Moore.* Dav. Supplementary Appendix to vol. i, p. 30; and Sup., pl. xii, figs. 10—14						×												
109	— septatum, *Moore.* Dav. Supplementary Appendix to vol. i, p. 30; and Sup., pl. xii, figs. 22—24						×												
109	— Forbesii, *Moore.* Sup., pl. xii, figs. 6—9						×												
110	— granulosum, *Moore.* Sup., pl. xii, figs. 1—5						×												
111	— sp. (?)														×				
111	Argiope (?) oolitica, *Dav.* Sup., pl. xi, figs. 16, 16 *a*								×										
112	Zellania Davidsoni, *Moore.* Sup., pl. xi, figs. 18, 19		×				×												
112	— Laboucheri, *Moore.* Sup., pl. xi, figs. 20, 21		×				×												
112	— liasiana, *Moore.* Sup., pl. xi, figs. 23, 24				×														
113	— globata, *Moore.* Sup., pl. xi, figs. 25—27							×	×						×				
113	— oolitica, *Moore.* Sup., pl. xi, fig. 28						×												
114	— obesa, *Moore.* Sup., pl. xi, fig. 22		×																
114	Terebratella Buckmani, *Moore.* Sup., pl. xiv, figs. 13, 14								×										
115	— furcata, *Sow.* Sup., pl. xiv, figs. 15—16								×										
115	— Moorei, *Dav.* Sup., pl. xiv, fig. 17								×										
116	(?) liasiana, *Desl.*			×															
116	Terebratulina radiata, *Moore.* Sup., pl. xiv, figs. 7—9								×										
117	— — var. Dundriensis, *Dav.* Sup., pl. xiv, fig. 10						×												
117	(?) Deslongchampsii, *Dav.*			×															
118	(?) granulosa, *Dav.* Ool. Mon., p. 18, pl. i, fig. 20; Sup., pl. xiv, figs. 11, 12				×														
119	Suessia imbricata, *E. Desl.*			×															
119	Terebratula (?) Suessi, *E. Desl.* Sup., pl. xiv, figs. 4, 5, 6			×															
120	— (?) Perrieri, *E. Desl.* Sup., pl. xiv, figs. 1, 2, 3			×															
121	— maxillata, *Sow.* Dav. Ool. Mon., p. 50, pl. ix, figs. 1—9						×		×	×	×								
122	— — var. sub-maxillata, *Morris.* Dav. Ool. Mon., p. 51, pl. ix, figs. 10—12					?	×												
122	— perovalis, *Sow.* Dav. Ool. Mon., p. 51, pl. x, figs. 1—6, var. *Kleinii*, Lam.; Sup., pl. xvii, fig. 9						×												
156	— — var. ampla, *Buckman.* Sup., pl. xxv, figs. 1, 2						×												
123	— Phillipsii, *Morris.* Dav. Ool. Mon., p. 53, pl. xi, figs. 6—8; and vol. i, Appendix A, fig. 14; Sup., pl. xvii, figs. 10, 17						×	×											
156	— — var. Phillipsiana, *Walker.* Sup., pl. xvii, fig. 23						×												
123	— intermedia, *Sow.* Ool. Mon., p. 52, pl. xi, figs. 1—5; Sup., pl. xvii, fig. 12								×		×								
156	— — var. Langtonensis, *Walker.* Sup., pl. xviii, fig. 14									×	×								

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124	TEREBRATULA, Joassi, *Dav.* Sup., pl. xv, fig: 4															×			
124	— bisuffarcinata, *Zieten*, non *Schloth.* (?). Sup., pl. xv, figs. 1, 2, 3																		
125	— insignis, *Schübler.* Sup., pl. xv, fig. 7													×					
125	— — var. Maltonensis, *Oppel.* Dav. Ool. Mon., p. 47, pl. xiii, fig. 1; and Sup., pl. xv, figs. 5, 6												×						
126	— Oxoniensis, *Walker.* Sup., pl. xv, figs. 8, 9														×				
127	— ventricosa, *Hartmann* (?). Sup., pl. xv, figs. 10, 11												×						
128	— Buckmani, *Dav.* Ool. Mon., p. 44, pl. vii, figs. 15, 16; Sup., pl. xix, fig. 13						×												
156	— — var. Buckmaniana, *Walker.* Sup., pl. xix, figs. 14—17						×												
128	— trilineata, *Young & Bird.* Dav. Ool. Mon., p. 48, pl. viii, figs. 6, 7; Sup., pl. xvi, figs. 1, 2 (not *T. ovoides*, Sow.)					×													
130	— punctata, *Sow.* Ool. Mon., p. 45, pl. vi, figs. 1—10, 12 and 16 (?); Sup., pl. xvi, figs. 6—8, 11, 12; and *var.* 9, 10 (?)		×	×	×	?													
131	— — var. Edwardsii, *Dav.* Ool. Mon., p. 30, pl. vi, figs. 11, 13, 14, 15; Sup., pl. xvii, fig. 22			×															
131	— — var. Radstockiensis, *Dav.* Sup., pl. xvi, figs. 14—18			×															
132	— — var. Havesfieldensis, *Dav.* Sup., pl. xvi, figs. 3, 4, 5					×													
133	— Jauberti, *E. Desl.* Sup., pl. xvii, fig. 13			×															
133	— ovoides, *Sow.* Dav. Ool. Mon., p. 48, pl. viii, figs. 4, 5 only; Sup., pl. i, figs. 12, 13 (14, 15, 16 ?). Uncertain whether Cretaceous or Jurassic																		
133	(?) Hudlestoni, *Walker.*, see *Wald. Hudlestoni.* Sup., pl. xvii, figs. 14—16																		
134	— sphæroidalis, *Sow.* Dav. Ool. Mon., p. 56, pl. ix, figs. 9—15, 18 (not 16, 17, 19); and Appendix to vol. i A, fig. 16; ? Sup., pl. xviii, fig. 15						×												
135	— anglica, *Oppel*, see *Wald. anglica.* Ool. Mon., Appendix to vol. i, pl. A, figs. 10—13; Sup., pl. xxiii, figs. 23—26																		
135	— globulina, *Dav.* Ool. Mon., p. 57, pl. xi, figs. 20, 21			×	×														
135 149	— globata, *Sow.* Ool. Mon., p. 54, pl. xiii, figs. 2, 3 (Sowerby's types), 4 (?), 5, 6, 7 (?); Sup., pl. xvii, fig. 3, 1 var.						×	×											
137	— — var. Fleischeri, *Oppel.* Dav. Ool. Mon., pl. xiii, fig. 7; Appendix to vol. i, pl. A, fig. 18; and Sup., pl. xvii, fig. 2, probably 1 also						×												
150	— — var. Birdlipensis, *Walker.* Sup., pl. xvii, figs. 18—21						×	×											
138	— Eudesei, *Oppel.* Dav. Ool. Mon., pl. xiii, fig. 4; and Sup., pl. xvii, fig. 4						×												
150	— Bradfordiensis, *Walker.* Dav. Sup., pl. xvii, fig. 6									×									

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138	Terebratula bullata, *Sow.*, see *Wald. bullata.* Dav. Ool. Mon., pl. xi, fig. 19; Sup., pl. xvii, fig. 5; pl. xxi, figs. 21, 22																		
139	— Fileyensis, *Walker.* Sup., pl. xiv, figs. 22, 24							×											
139	— Ferryi, *E. Desl.* Sup., pl. xvii, figs. 7, 8						×												
140	— Etheridgii, *Dav.* Appendix to vol. i, p. 20, pl. A, figs. 7, 8						×												
140	— Wrightii, *Dav.* Appendix to vol. i, p. 20 (two woodcut figures)						×												
140	— simplex, *Buckman.* Dav. Ool. Mon., p. 48, pl. viii, figs. 1—3						×												
140	— plicata, *Buckman.* Dav. Ool. Mon., p. 60, pl. xii, figs. 1—5						×												
141	— fimbria, *Sow.* Dav. Ool. Mon., p. 61, pl. xii, figs. 6—12; Sup., pl. xx, fig. 3						×												
141	— Bentleyi, *Dav.* Ool. Mon., p. 58, pl. xiii, figs. 9, 10, 11; and Appendix to vol. i, p. 19; Sup., pl. xxv, fig. 4										×								
142	— galeiformis, *M'Coy = T. sub-Bentleyi*, Dav. Ool. Mon., p. 59, pl. xiii, fig. 11; and Appendix to vol. i, p. 19, pl. A, fig. 15						×												
142	— flabellum, *Desl.* Dav. Ool. Mon., p. 62, pl. xii, figs. 19—21								×	×									
142	— hemisphærica, *Sow.* Dav. Ool. Mon., p. 64, pl. xiii, figs. 17, 18								×	×									
142	(?) minuta, *Moore.* Dav. Sup., pl. xvii, fig. 11 (not 12)								×										
143	— coarctata, *Park.* Dav. Ool. Mon., p. 59, pl. xii, figs. 12, 14; and Sup., pl. xiv, figs. 18, 19								×	×									
144	— — var. reticulata, *Sow.* Dav. Ool. Mon., pl. xii, fig. 15; Sup., pl. xiv, figs. 20, 21; and Sup., pl. xxv, fig. 3					×	×	×											
145	— infra-oolitica, *E. Desl.* Sup., pl. xviii, figs. 8, 9					×													
147	— Stephani, *Dav.* Sup., pl. xviii, figs. 1—7						×												
148	— subsella, *Leymerie.* Dav. Sup., pl. xix, figs. 10, 11, 12															×			
151	— decipiens, *E. Desl.* Dav. Ool. Mon., pl. xi, figs. 16, 17; and Sup., pl. xx, figs. 4—8						×												
151	— Craneæ, *Dav.* Sup., pl. xx, figs. 1, 2						×												
152	— Whitakeri, *Walker.* Sup., pl. xix, figs. 6—9						×												
153	— curvifrons, *Oppel.* Dav. Ool. Mon., pl. iv, figs. 15, 16; Appendix to vol. i, pl. A, fig. 17; and Sup., pl. xxiv, fig. 33						×												
154	— Boloniensis, *Sauvage* and *Rigaux.* Dav. Sup., pl. xix, figs. 1 and 2												?						
155	— Gesneri, *Élaton*? Dav. Sup., pl. xix, figs. 4, 5														×	×			
156	(?) Walfordi, *Dav.* Sup., pl. xix, figs. 18, 19			×															
157	Waldheimia quadrifida, *Lam.* Dav. Ool. Mon., p. 28, pl. iii, figs. 8—10; Sup., pl. xxi, fig. 20			×															
158	— — var. cornuta, *Sow.* Dav. Ool. Mon., p. 29, pl. iii, figs. 11—18; Sup., pl. xxi, fig. 19			×															

Supplement page.	Genus, Species, and Reference to Plates.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Passage Beds, Midford Sands.	Inferior Oolite.	Fuller's Earth.	Great Oolite and Stonesfield Slate.	Forest Marble and Bradford Clay.	Cornbrash.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit Passage Bed.	Coralline Limestone.	Supra-Coralline.	Kimmeridge Clay.	Portland.	Purbeck.
158	Waldheimia Mariæ, *d'Orb.* Sup., pl. xxi, figs. 16, 17, 18	..	...	×															
159	— indentata, *Sow.* Dav. Ool. Mon., p. 46, pl. v, figs. 25, 26; Sup., pl. xxi, figs. 10—15	...	...	×															
161	— emarginata, *Sow.* Dav. Ool. Mon., p. 35, pl. iv, figs. 18–21; and Sup., pl. xxiii, figs. 5, 6, 7	...	...	...	...	...	×												
161	— Waltoni, *Dav.* Ool. Mon., p. 36, pl. v, figs. 1—3; and Sup., pl. xxiii, figs. 8, 9, 10	...	...	...	...	×	×												
162	— numismalis, *Lam.* Dav. Ool. Mon., p. 36, pl. v, figs. 4—9; and Sup., pl. xxi, figs. 8, 9	...	×	×															
162	— sub-numismalis, *Dav.* Ool. Mon., p. 38, pl. v, fig. 10; Sup., pl. xxi, figs. 1—7	...	...	×															
163	— Darwini, *E. Desl.* Dav. Sup., pl. xxiv, figs. 9, 10, 11	...	...	×															
164	— perforata, *Piette.* Sup., pl. xxiv, figs. 1, 2, 3, 5 ?	...	×	×															
167	— ornithocephala, *Sow.* Dav. Ool. Mon., p. 40, pl. vii, figs. 6, 7, 8, 10, 13, and 23 (not 7, 8); Sup., pl. xxii, figs. 1, 2; and pl. xxiv, fig. 27	...	...	...		..	× ?	×	...	...	× ?								
168	— — var. Kellowayensis, *Dav.* Sup., pl. xxiv, figs. 28, 29	...	...	...	...	..	...	...	...	..	...	×							
168	— lagenalis, *Schl.* Dav. Ool. Mon., p. 42, pl. vii, figs. 1—4, 14	...	...	...	...	..	...	...	...	..	×								
168	— umbonella, *Lam.* Dav. Sup., pl. xxii, figs. 7, 8	...	...	...	...	..	...	...	.	...	...	×	×						
169	— lampas, *Sow.* Dav. Sup., p. 169, pl. xxii, figs. 3—6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×			
170	— Cadomensis, *E. Desl.* Dav. Ool. Mon., pl. vii, fig. 9; and Sup., pl. xx, fig. 9; and pl. xxiv, figs. 14, 15	...	...	...	...	..	×	×											
171	— obovata, *Dav.* Ool. Mon., p. 39, pl. v, figs. 14—17, and pl. vii, fig. 5; Sup., pl. xxii, figs. 10, 11	...	...	...	...	..	...	...	...	...	×	...	?						
172	— — var. Siddingtonensis, *Walker.* Sup., pl. xxii, figs. 12, 13, 14	...	...	...	...	..	...	...	...	..	×								
172	— — var. sub-ovata, *Walker.* Sup., pl. xxii, figs. 15, 16	...	...	...	...	...	...	...	...	...	×								
172	— — var. Stiltonensis, *Walker.* Sup., pl. xxii, figs. 17, 18, 19, 20	...	...	...	...	...	...	.	...	...	×								
173	— digona, *Sow.* Dav. Ool. Mon., p. 38, pl. v, figs. 18—24; and Sup., pl. xxii, figs. 21, 22	...	...	...	...	...	...	...	×	×									
173	— bucculenta, *Sow.* Dav. Ool. Mon., p. 55, pl. xiii, fig. 8; and Sup., pl. 22, fig. 23 and pl. xxiv, figs. 23—26	...	...	...	...	...	...	...	...	...	...	...	?	×	×				
174	— Waterhousi, *Dav.* Ool. Mon., p. 31, pl. v, figs. 12, 13	...	...	×															
174	— Hughesi, *Walker*, MS.	...	...	...	...	...	×												
175	— Lycetti, *Dav.* Ool. Mon., p. 44, pl. vii, figs. 17—22; and Sup., pl. xxiv, figs. 30. 31	...	...	...	×														
178	— Dorsetiensis, *Walker.* Sup., pl. xxiv, figs. 6, 7, 8.	...	...	...	...	..	...	...	..	...	...	...	...	...	...	×			
176	— margarita, *Oppel.* Sup., pl. xxiv, figs. 12, 13	...	...	...	...	...	...	...	...	...	...	...	...	...	×				
177	— resupinata, *Sow.* Ool. Mon., p. 31, pl. iv, figs. 1—5	...	...	×															
178	— florella, *d'Orb.* Dav. Sup., pl. xxiii, figs. 11, 12, 13	...	...	×															
179	— Moorei, *Dav.* Ool. Mon., p. 33, pl. iv, figs. 6, 7	...	...	×															
179	— Backeriæ, *Dav.* Ool. Mon., p. 38, pl. v, fig. 11	...	...	×															

Supplement page.	Genus, Species, and Reference to Plates.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Passage Beds, Midford Sands.	Inferior Oolite.	Fuller's Earth.	Great Oolite and Stonesfield Slate.	Forest Marble and Bradford Clay.	Cornbrash.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit Passage Bed.	Coralline Limestone.	Supra-Coralline.	Kimmeridge Clay.	Portland.	Purbeck.
179	Waldheimia carinata, *Lam.* Dav. Ool. Mon., p. 35, pl. iv, figs. 11—14 (not 15, 16, 17)); Sup., pl. xxiii, figs. 14, 15						×												
180	— — var. Mandelslohi, *Oppel.* Dav. Sup., pl. xxiii, figs. 16, 17, 18						×												
181	— — var. Blakei, *Walker.* Dav. Sup., pl. xxiii, figs. 19, 20						×												
181	— Meriani, *Oppel.* Dav. Ool. Mon., p. 33, pl. iv, fig 8, and pl. x, fig. 7						×												
182	— impressa, *von Buch.* Dav. Ool. Mon., p. 33, pl. iv, figs. 9, 10 (not 8); Sup., pl. xxiv, fig. 22												×						
183	— Leckenbyi, *Walker.* Dav. Ool. Mon., Appendix to vol. i, pl. A, fig. 19; Sup., pl. xxiii, figs. 1—4						×												
183	(?) humeralis, *Roemer.* Dav. Sup., pl. xxiv, figs. 18, 19															×			
185	— sp. ? Sup., pl. xxiv, fig. 20												×						
185	— cardium, *Lam.* Dav. Ool. Mon., p. 43, pl. xii, figs. 13—18; and Sup., pl. xxiv, figs. 21, 22						×	×	×	×									
186	— (Terebratula) Anglica, *Oppel.* Sup., pp. 135 and 186, pl. xxiii, figs. 23—26						×												
186	— — Hudlestoni, *Walker.* Sup., pp. 135 and 186, pl. xvii, figs. 14, 15, 16												×						
187	— — bullata, *Sow.* Dav. Sup., pl. xxi, figs. 21, 22					×													
188	Rhynchonella Wrightii, *Fischer.* Dav. Ool. Mon., p. 69, pl. xiv, fig. 1; and Appendix to vol. i, p. 21, pl. A, fig. 27						×												
189	— furcillata, *Theodori.* Dav. Ool. Mon., p. 69, pl. xiv, figs. 2—5; and Sup., pl. xxvii, figs. 1, 2, 3			×	×														
189	— rimosa, *von Buch.* Dav. Ool. Mon., p. 70, pl. xiv, figs. 6, 6 *a*; Sup., pl. xxvii, fig. 10			×															
189	— serrata, *Sow.* Dav.—Ool. Mon., p. 85, pl. xvi, figs. 1, 2			×															
190	— plicatella, *Sow.* Dav. Ool. Mon., p. 86, pl. xvi, figs. 7, 8; and Sup., pl. xxvii, figs. 4, 5, 6, 7						×												
190	— Sutherlandi, *Dav.* Sup., pl. xxv, figs. 5, 6, 7, 8															×			
191	— inconstans, *Sow.* Dav. Ool. Mon., p. 87, pl. xviii, figs. 1—4; and Sup., pl. xxvi, figs. 1—6																×		
193	— pinguis, *Roemer.* Dav. Sup., pl. xxvi, fig. 7															×			
194	— — var. pectunculoides, *Étalon.* Dav. Sup., pl. xxvi, figs. 8—12															×			
196	— lacunosa, *Schloth.* Dav. Sup., pl. xxvi, figs. 13, 14												×						
197	— Boueti, *Dav.* Sup., pl. xxvi, figs. 15, 16								×	×									
198	— tetrahedra, *Sow.* Dav. Ool. Mon., p. 93, pl. xviii, figs. 5, 9, not 10			×	×														
199	— — var. Dumbletonensis, *Dav.* Sup., pl. xxix, fig. 5			×															
199	— — var. Northamptonensis, *Dav.* Sup., pl. xxix, figs. 7—12			×															
200	— sub-tetrahedra, *Dav.* Ool. Mon., p. 95, pl. xvi, figs. 9—12						×												

Supplement page.	Genus, Species, and Reference to Plates.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Passage Beds, Midford Sands.	Inferior Oolite.	Fuller's Earth.	Great Oolite and Stonesfield Slate.	Forest Marble and Bradford Clay.	Cornbrash.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit Passage Bed.	Coralline Limestone.	Supra-Coralline.	Kimmeridge Clay.	Portland.	Purbeck.
200	Rhynchonella Amalthei, *Quenstedt.* Dav. Sup., pl. xxviii, figs. 18—20, 21			×	×														
201	— sub-decorata, *Dav.* Ool. Mon., pl. xviii, fig. 10; and Appendix to vol. i, p. 21, pl. A, figs. 23—26						×												
201	(?) quadriplicata, *Zieten.* Appendix to vol. i, pl. A, figs. 22; and Sup., pl. xxix, figs. 1, 2, 3						×												
202	— pygmæa (Ter.), *Morris.* Ool. Mon., p. 57, pl. xiii, fig. 16				×														
203	— Lycetti, *Dav.* Ool. Mon., p. 81, pl. xv, fig. 6						×												
203	— Moorei, *Dav* Ool. Mon., p. 82, pl. xv, figs. 11—14			×	×														
203	— sub-variabilis, *Dav.* Ool. Mon., p. 80, pl. xv, fig. 7, and pl. xviii, fig. 11																		
203	— acuta, *Sow.* Dav. Ool. Mon., p. 76, pl. xiv, figs. 8, 9			×												×			
204	— cynocephala, *Richard.* Dav. Ool. Mon., p. 77, pl. xiv, figs. 10—12			×	×	×	×												
204	— ringens, *Herault.* Dav. Ool. Mon., p. 74, pl. xiv, figs. 13—16; Sup., pl. xxvii, figs. 14—16						×												
205	— sub-ringens, *Dav.* Ool. Mon., p. 75, pl. xiv, figs. 17, 17 *a*, *b*, *c*						×												
205	— Bouchardii, *Dav.* Ool. Mon., p. 82, pl. xv, figs. 3—5; Sup., pl. xxix, fig. 19				×														
205	— oolitica, *Dav.* Ool. Mon., p. 81, pl. xiv, fig. 7						×												
205	— Forbesii, *Dav.* Ool. Mon., p. 84, pl. xvii, fig. 9						×												
205	— concinna, *Sow.* Dav. Ool. Mon., p. 88, pl. xvii, figs. 6—12; Sup., pl. xxvii, fig. 22							?	×	×	×								
206	— — var. Yaxleyensis, *Dav.* Sup., pl. xxvii, fig. 23										×								
206	— sub-concinna, *Dav.* Ool. Mon., p. 90, pl. xvii, fig. 17			×															
206	— fodinalis, *R. Tate.* Sup., pl. xxviii, figs. 39—41			×															
207	— obsoleta, *Sow.* Dav. Ool. Mon., pl. xvii, figs. 1—5; var., Sup., pl. xxix, fig. 4						×	?	×										
207	— sub-obsoleta, *Dav.* Ool. Mon., pl. xvii, fig. 14					×	×												
207	— angulata, *Sow.* Dav. Ool. Mon., p. 92, pl. xvii, fig. 13						×												
208	— — var. sub-angulata, *Dav.* Sup., pl. xxix, figs. 14—16						×												
208	— variabilis, *Schloth.* Dav. Ool. Mon., p. 78, pl. xv, figs. 8—10		×	?															
209	— lineata, *Young & Bird.* Dav. Ool. Mon., pl. xvi. figs. 1 and 3 only; Sup., pl. xxix, figs. 17, 18			×															
210	— — var. Radstockiensis, *Dav.* Ool. Mon., pl. xvi, figs. 4 and 6			×															
210	— oxynoti, *Quenstedt.* Dav. Sup., pl. xxviii, figs. 37, 38		×	×															
211	— triplicata, juvenis, *Quenstedt.* Dav. Ool. Mon., pl. xvi, figs. 2 and 5 (not *Rh. variabilis*); and Sup., pl. xxviii, figs. 35, 36		×																
212	— varians, *Schlotheim.* Dav. Sup., pl. xxviii, figs. 3 *a*, 3 *b*, 4, 12, and 13							?	?	?	?	×	×	×					
213	— — var. Smithii, *Walker.* Dav. Ool. Mon., p. 83, pl. xvii, figs. 15, 16; Sup., pl. xxviii, figs. 1, 2, 3							×					×						

Supplement page.	Genus, Species, and Reference to Plates.	Rhætic.	Lower Lias.	Middle Lias.	Upper Lias.	Passage Beds, Midford Sands.	Inferior Oolite.	Fuller's Earth.	Great Oolite, Stonesfield Slate.	Forest Marble and Bradford Clay.	Cornbrash.	Kelloway Rock.	Oxford Clay.	Lower Calcareous Grit Passage Beds.	Coralline Limestone.	Supra-Coralline.	Kimmeridge Clay.	Portland.	Purbeck.
214	Rhynchonella varians, var. socialis, *Phillips*. Dav. Sup., pl. xxviii figs. 8—11										×	×							
214	— — var. spathica, *Lam.* ? Dav. Sup., pl. xxviii. figs. 5, 6, 7											×	×						
215	— — var. Thurmanni, *Voltz*. Dav. Sup., pl. xxviii, figs. 14, 15, 16													×					
216	— Leedsii, *Walker*. Dav. Sup., pl. xxviii, fig. 17										×								
216	— egretta, *E. Desl.* Dav. Sup., pl. xxviii, fig. 23			×															
217	(?) Lopensis, *Moore*. Dav. Sup., pl. xxvii, figs. 8, 9						×												
218	(?) coronata, *Moore*. Dav. Sup., pl. xxvii, fig. 13				×														
218	— Tatei, *Dav.* Sup., pl. xxviii, fig. 45						×												
219	— parvula, *E. Desl.* Sup., pl. xxvii, fig. 21						×												
220	— Stephensi, *Dav.* Sup., pl. xxvii, fig. 21						×												
220	— calcicosta, *Quenstedt*. Dav. Sup., pl. xxviii, figs. 24—33		×	×															
221	— Glevensis, *Smithe*. Dav. Sup., pl. xxviii, fig. 22		×																
222	— capitulata, *Tate*. Dav. Sup., pl. xxvii, figs. 11, 12			×															
222	— spinosa, *Schloth*. Dav. Ool. Mon., p. 71, pl. xv, fig. 15—20						×	×											
222	— — var. Bradfordiensis, *Walker*. Dav. Sup., pl. xxvii, fig. 18									×									
223	— Crossi, *Walker*. Dav. Sup., pl. xxvii, fig. 17						×												
223	— senticosa, *von Buch*. Dav. Ool. Mon., p. 73, pl. xv, fig. 21						×												
224	— Jurensis, *Quenstedt*. Dav. Sup., pl. xxvii, figs. 24—27				×														
225	— Morierei, *Dav.* Ool. Mon., p. 92, pl. xviii, figs. 12, 13										×								

SUPPLEMENT, PLATE XVII.

Fig.

1. *Terebratula globata*, Sow., var. Upper Inferior Oolite, Cheltenham. Collection of Author. (Pp. 135 and 149.)

2. „ „ An elongated form of the same species. *T. Fleischeri*, Oppel (one of his type specimens). Same formation and locality. Collection of Author. (P. 137.)

3. „ „ A typical example of *T. globata*, Sow. Collected by Mr. J. F. Walker from the Fuller's-earth Rock (a rubbly Oolite with clay between), along with *Wald. bullata* and *Rh. varians*, var. *Smithii*, in a cutting along the road side at Whatley, near Frome and Nunney. (Pp. 135 and 149.)

4. „ *Eudesi*, Oppel. Inferior Oolite, Dundry. (P. 138.)

5. *Waldheimia* (*Ter.*) *bullata*, Sow. A typical example, Fuller's Earth, near Frome. (P. 138.)

6. *Terebratula Bradfordiensis*, Walker. Bradford Clay, Tetbury Road Station (mentioned at P. 140 of this Supplement). (P. 150.)

7, 8. „ *Ferryi*, E. Desl. Inferior Oolite, Bradford Abbas, Dorsetshire. Collection of Mr. J. F. Walker. (P. 139.)

9. „ *perovalis*, var. *Kleinii*, Lamarck. From a sandy bed under "Trigonia Grit," Leckhampton Hill, Cheltenham. Collection of Mr. Walker. (P. 123.)

10. „ *Phillipsii*. Inferior Oolite, Bradford Abbas. Collection of Prof. Buckman. (P. 123.)

11, 11 *a*. „ *minuta*, Moore. Great Oolite, Hampton Cliff, Bath (probably the fry of some other species). Efface the No. 12 at p. 142, which belongs to *T. intermedia*. (P. 142.)

12. „ *intermedia*, Sow. Cornbrash, Wollaston. Showing traces of the original colour in radiating stripes. Collection of British Museum. (P. 123.)

13. „ *Jauberti*, E. Desl. Marlstone, Middle Lias, near Ilminster. Museum of School of Mines. (P. 133.)

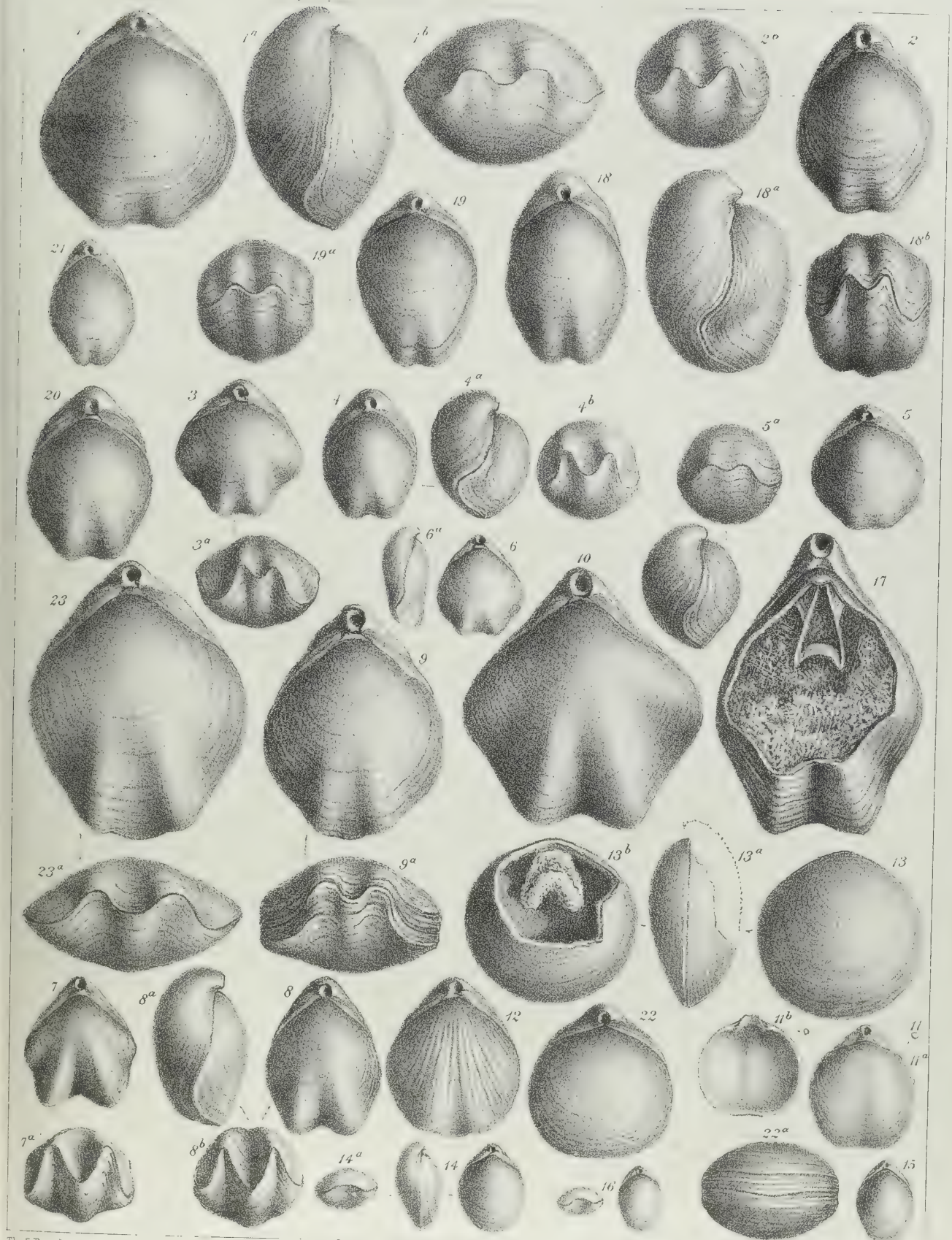
14—16. *Waldheimia* (*Ter.*) *Hudlestoni*, Walker. Lower Calcareous Grit, Filey, Yorkshire coast. Collection of Mr. Walker. (Described as a *Terebratula*? at p. 133 of this Supplement.)

17. *Terebratula Phillipsii*, Morris. Showing loop. After a figure by Prof. E. Desl. 'Brach. Jur.,' pl. lxvii, fig. 3. (P. 123.)

18—21. „ *globata*, var. *Birdlipensis*, Walker. "Clypeus Grit," Inferior Oolite, Birdlip Hill, near Cheltenham. (This is the form alluded to by Lycett, "Cotteswold Hill," p. 134.) Collection of Mr. J. F. Walker. (P. 150.)

22. „ *punctata*, var. *Edwardsii*, Dav. A remarkable specimen. Marlstone, Middle Lias, Chideock, near Charmouth, Dorsetshire. Collection of Mr. J. F. Walker. (P. 131.)

23. „ *Phillipsii*, Morris, var. *Phillipsiana*, Walker. A broad variety. Inferior Oolite, Cleeve Hill, Gloucestershire. Collection of Mr. J. F. Walker. (P. 156.)



Thos Davidson del et lith

M & N Hanhart imp

SUPPLEMENT, PLATE XVIII.

Fig.

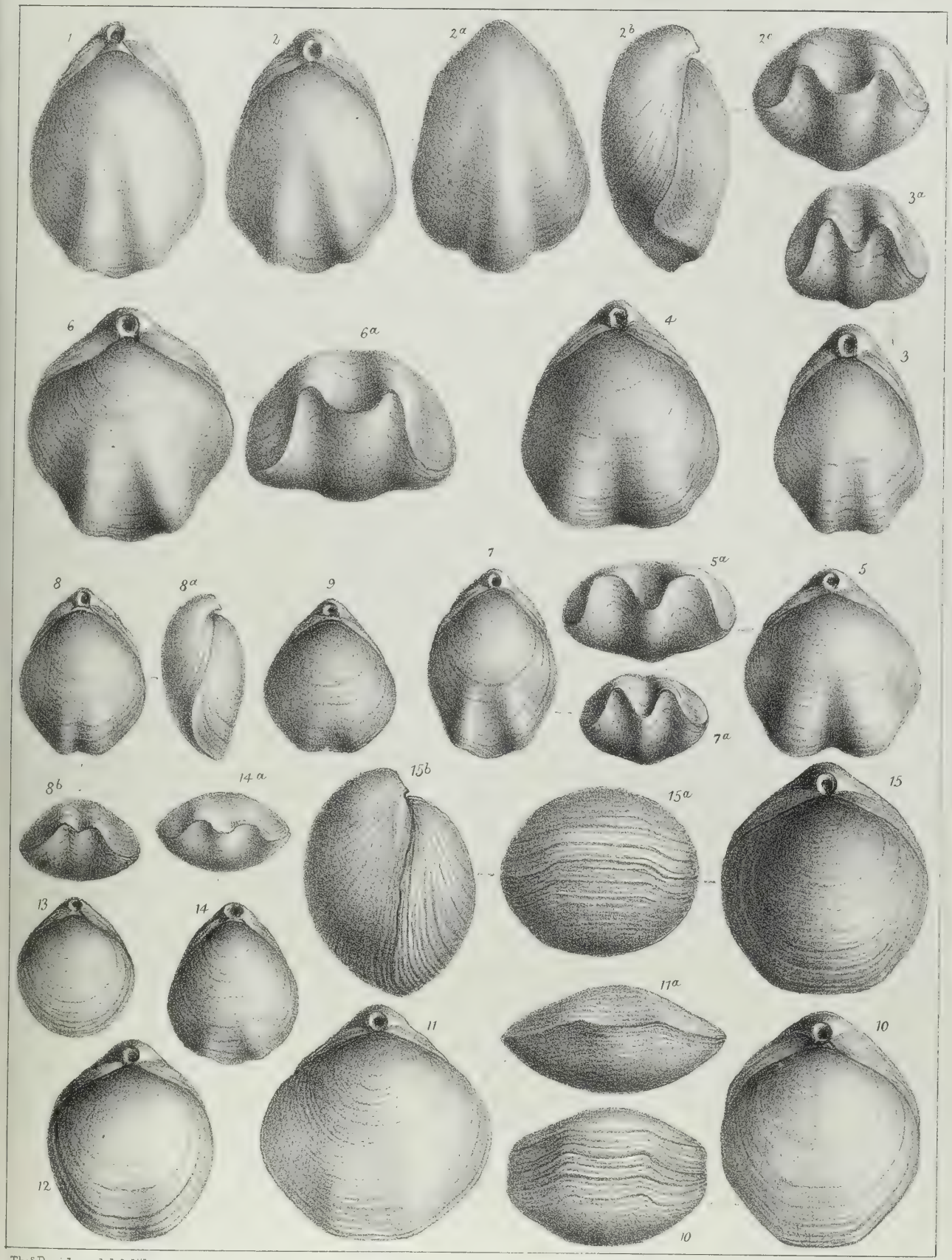
1—7. *Terebratula Stephani*, Dav. Inferior Oolite. 1. Bradford Abbas. Collection of Mr. J. F. Walker. 2, 3. Same locality. Collection of Mr. Darell Stephens. 4, 5. Broadwinsor. 6, 7. Bradford Abbas. Collection of Prof. Buckman. (P. 147.)

8—9. „ *Infra-Oolitica*, E. Desl. *Am. Jurensis* zone, Upper Lias or Passage Bed, Frocester Hill, Gloucestershire. (P. 145.)

10—13. „ *perovalis*, Sow. A small variety. Gryphea Grit, Inferior Oolite, Leckhampton Hill, Cheltenham. Collection of Mr. J. F. Walker. (P. 122.)

14. „ *intermedia*, Sow., var. *Langtonensis*, Walker. Cornbrash, Langton Herring, near Weymouth. Collection of Mr. J. F. Walker. (P. 156.)

15. „ *sphæroidalis*, var.? Oolitic Marl, Inferior Oolite, Crickley Hill, Gloucestershire. Seems intermediate in shape between *T. sphæroidalis* and *T. fimbria*.



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SUPPLEMENT, PLATE XIX.

Fig.

1—2. *Terebratula Boloniensis,* Rigaux and Sauvage. 1. Coral Rag, Bullingdon Pit, Shotover Hill, Oxford. 2. Coral Rag, Malton, Yorkshire. Leckenby's Collection, Woodwardian Museum, Cambridge. (P. 154.)

3. „ ? Something like *T. Boloniensis.* Oxford Clay, St. Clement's, Oxford. Collection of Mr. J. Parker. (P. 155.)

4, 5. „ *Gesneri* (?), Étalon. Coral Rag, Bullingdon Pit, Shotover Hill, Oxford. Collection of Mr. J. Parker. (P. 155.)

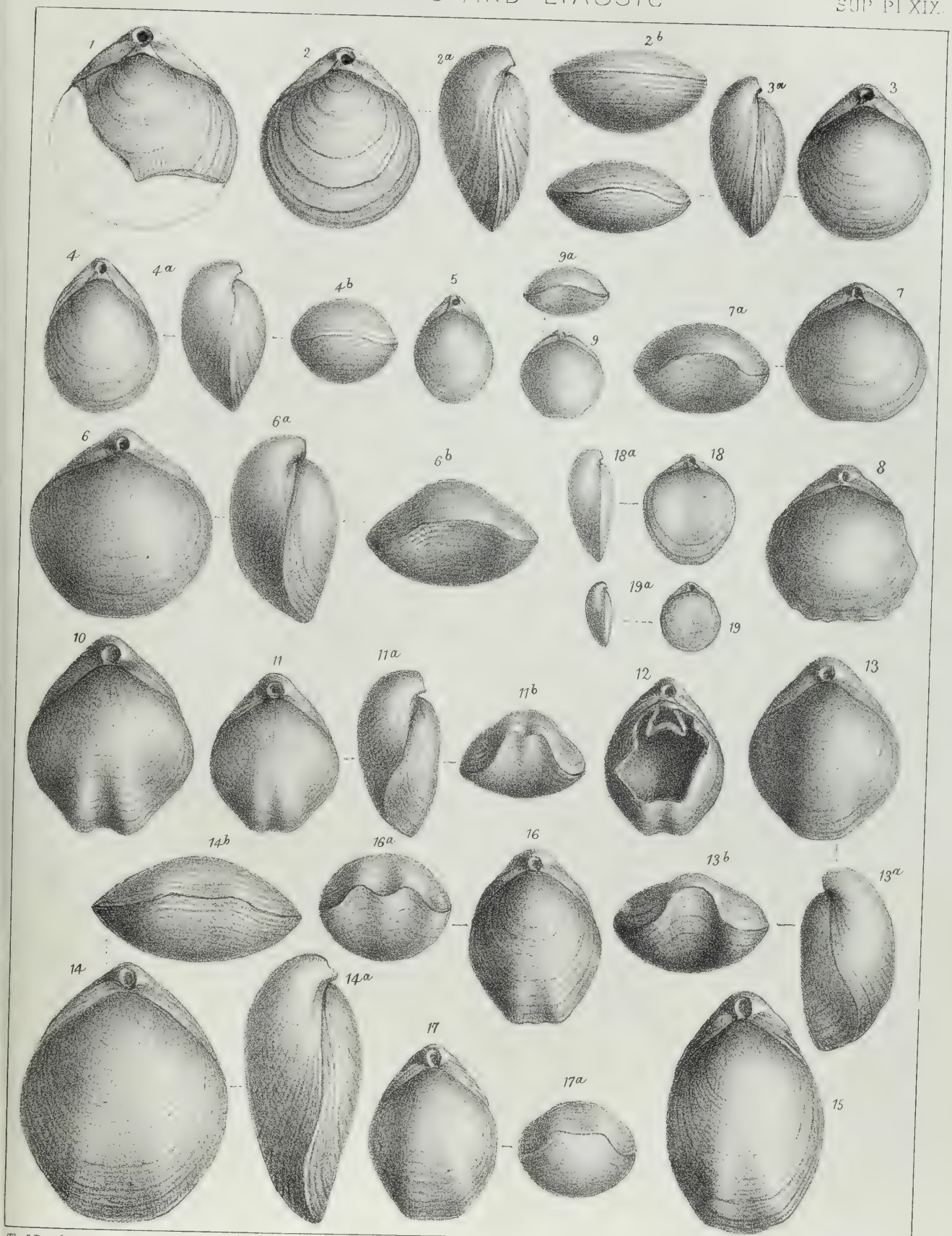
6—9. „ *Whitakeri,* Walker, MS. Oolite Marl, Inferior Oolite, Leckhampton, and Crickley Hills, near Cheltenham. Collection of Mr. J. F. Walker. (P. 152.)

10—12. „ *subsella,* Leymerie. Supra-Coralline, Abbotsbury, near Lyme Regis, Dorsetshire. Collection of Mr. J. F. Walker. (P. 148.)

13. „ *Buckmani,* Dav. Inferior Oolite, Crickley Hill, near Cheltenham. Collection of Dr. Wright. (P. 128.)

14—17. „ „ var. *Buckmaniana,* Walker. 14. "Gryphea Grit," Inferior Oolite, Leckhampton Hill, Cheltenham. Collection of Mr. J. F. Walker. 15, 16, 17. Biplicated form. Cleve Hill. 15. Collection of Mr. Walker. (P. 156.)

18, 19. „ *Walfordi,* Dav. 18. Marlstone, Middle Lias, Aston-le-Walls, near Banbury, Northamptonshire. 19. Same formation, Adderbury, near Banbury, Oxfordshire. Collection of Author. (P. 156.)



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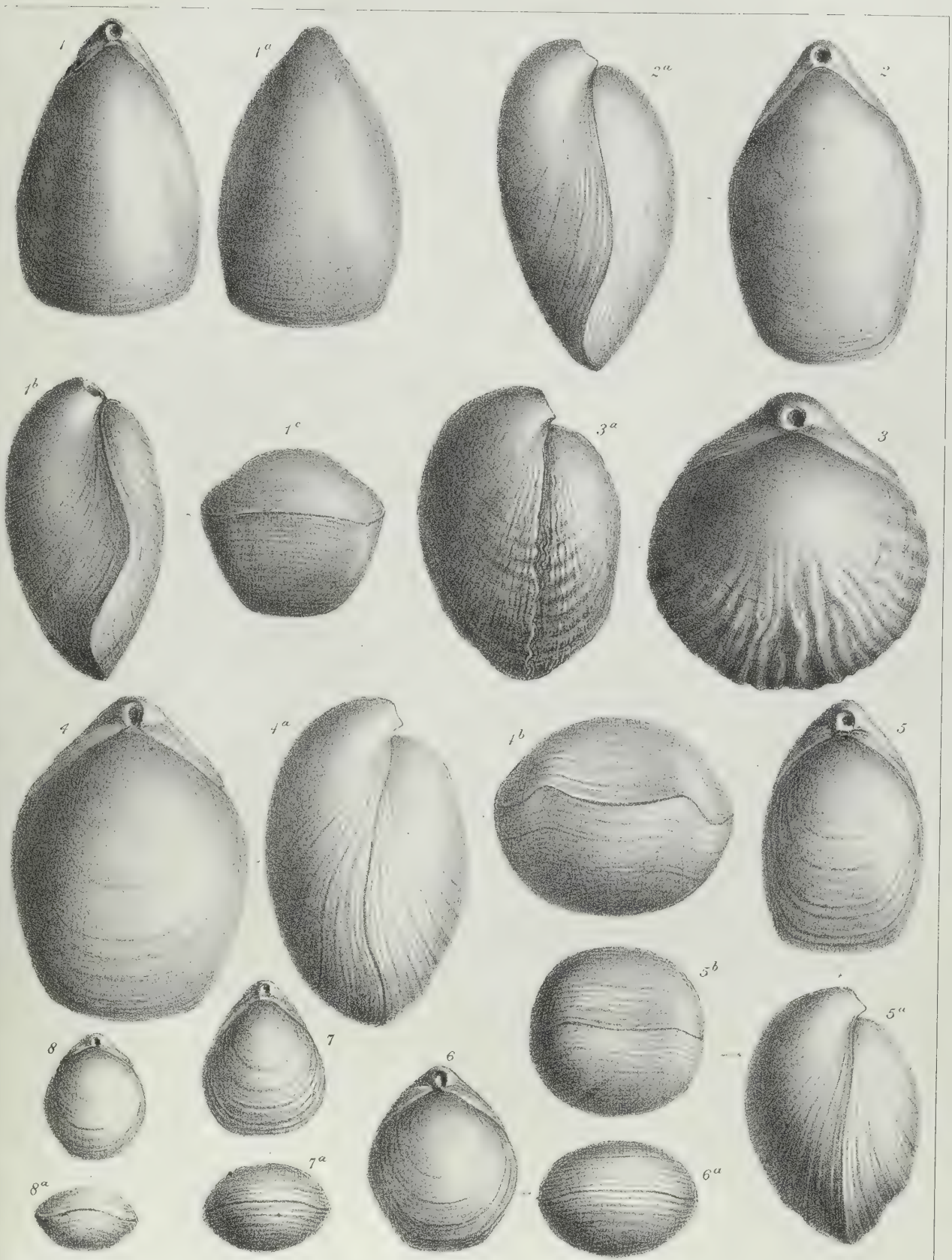
SUPPLEMENT, PLATE XX.

Fig.

1, 2. *Terebratula Craneæ*, Dav. Inferior Oolite, near Sherborne. 1. My Collection. 2. Collection of Mr. Darell Stephens. (P. 151.)

3. „ *fimbria*, Sow. The largest example hitherto collected. Inferior Oolite, Leckhampton Hill, near Cheltenham. Collection of Mr. J. F. Walker. (P. 141.)

4—8. „ *decipiens*, E. Deslong. Inferior Oolite. 4, 5, 6. Bradford Abbas, Sherborne. Collection of Professor Buckman. 7, 8. Crewkerne Station. Collection of Mr. Darell Stephens. (P. 151.)



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SUPPLEMENT, PLATE XXI.

Fig.

1—7. *Waldheimia sub-numismalis*, Dav. 1. A large thick specimen. Middle Lias, near Bradford Abbas, Dorsetshire. Collection of Mr. D. Stephens. 2. Middle Lias, Chideock, near Charmouth, Dorsetshire. School of Mines. 3, 6, 7. Different ages. Same locality. Collection of Mr. Walker. 4. A thick specimen. Middle Lias, *Am. marginatus* zone, Churchdown, Gloucestershire. 5. A specimen showing the loop. Museum of the School of Mines. (P. 162.)

8, 9. ,, *numismalis*, Lam. Lower Middle Lias, Churchdown, Gloucestershire. 9. An elongated specimen from *Am. Jamesoni* zone, lowest portion of Middle Lias, near Cheltenham. Mr. Deslongchamps refers these specimens to *Wald. cor.*, Lam., but I think them variations in shape of *W. numismalis*. Collection of author. (P. 162.)

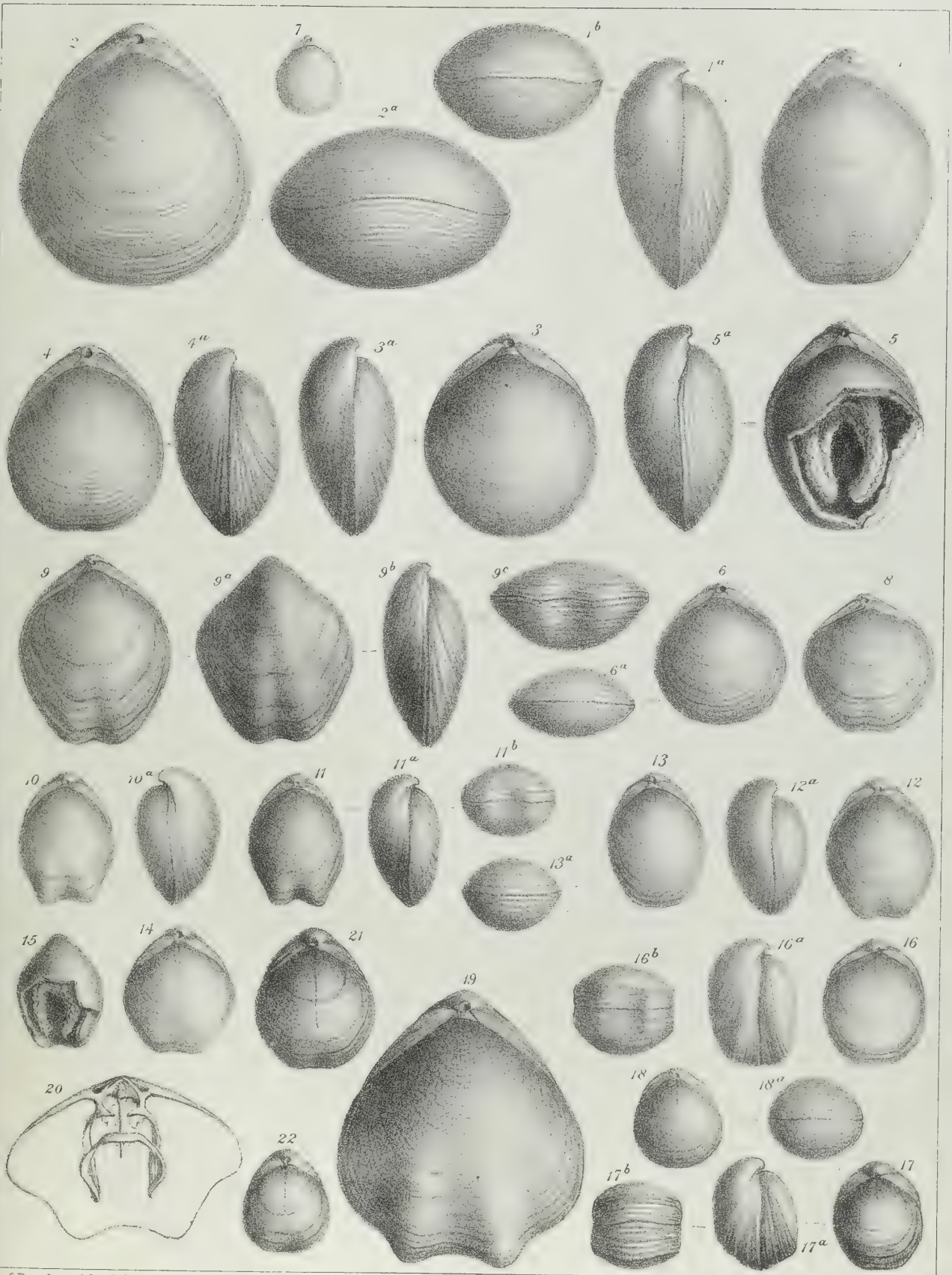
10—15. ,, *indentata*, Sow. 10. From Sowerby's type in British Museum. Middle Lias, near Banbury. 11. Another specimen. Same locality. Collection of Mr. Beesley. 12, 13. Two modifications in shape, showing the passages from the indentated front to the non-indentated. Middle Lias (*Am. spinatus* zone), Churchdown, Gloucestershire. 14. A wide specimen from Middle Lias, near Banbury. All the specimens figured in this Supplement from the Liassic deposits of Churchdown were collected and kindly given to me by the Rev. F. Smithe. (P. 159.)

16—18. ,, *Mariæ*, d'Orb. 16 and 16 *a b*. A typical example from the Middle Lias (*Am. margaritatus* zone) of Churchdown, Gloucestershire. 17. Middle Lias, South Petherton, near Ilminster. 18. From Charmouth, near Lyme Regis, and Collection of Mr. J. F. Walker. (P. 158.)

19. ,, *cornuta*, Sow. A very large example. Middle Lias, Chideock. Museum of the School of Mines. (P. 158.)

20. ,, *quadrifida*, Lam. After E. Deslong., to show the loop. (P. 157.)

21, 22. ,, (*Ter.*) *bullata*, Sow., to show the dark longitudinal line extending from the umbo to about two thirds of the length of the valve, indicating the presence of an internal septum and Waldheimia loop. Fuller's Earth, Whatley, near Frome, and Collection of Mr. J. F. Walker. (Pp. 138 and 187.)



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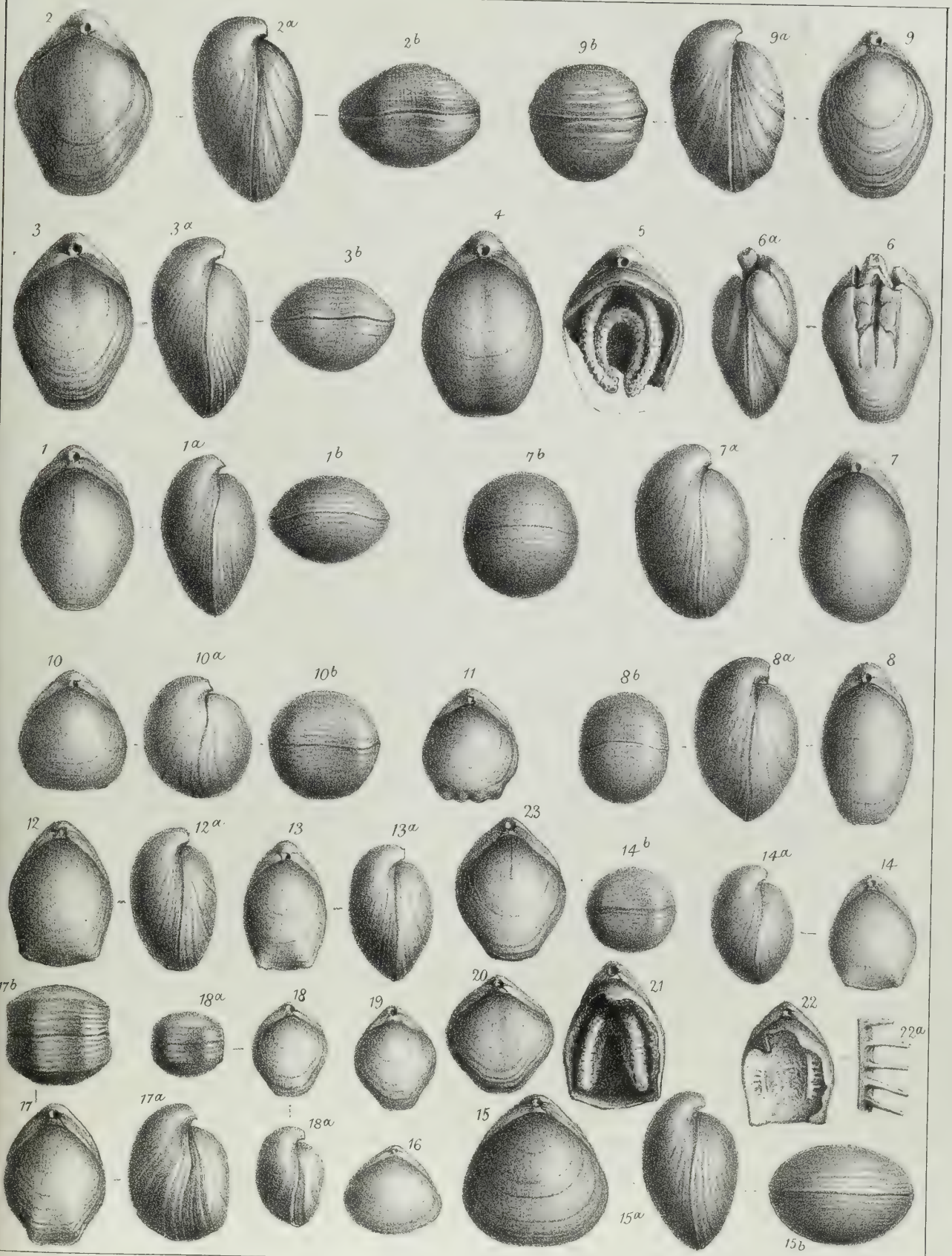
SUPPLEMENT, PLATE XXII.

Fig.		
1, 2.	*Waldheimia ornithocephala*, Sow.	1. From the original example. 'Min. Con.,' Tab. 101, fig. 1. Cornbrash of Chatley. British Museum. 2. Fuller's Earth, near Bath. (Pp. 165 and 167.)
3—5.	„ *lampas*, Sow.	Supra-Coralline Bed, Abbotsbury, Dorsetshire. Collection of Mr. Walker. 5. A specimen showing the long loop. (P. 169.)
6.	„ „	(Internal cast.) From the original example figured by Sowerby ('Min. Con.,' Tab. 101, fig. 3) from near Lyme Regis, Dorsetshire. British Museum. (P. 169.)
7, 8.	„ *umbonella*, Lam.	Kelloway Rock, Scarborough. Collection of Mr. J. F. Walker. (P. 168.)
9.	„ *Cadomensis*, E. Desl.	Inferior Oolite, Charlcomb, near Bath. Collection of author. (P. 170.)
10.	„ *obovata*, Sow., var. *perobovata*, Walker.	Cornbrash, Yaxley, near Peterborough. Collection of Mr. J. F. Walker. (P. 171.)
11.	„ „	A specimen from same locality, showing a tendency to the formation of folds close to its frontal margin. Collection of author. (P. 171.)
12.	„ „	var. *Siddingtonensis*, Walker. Cornbrash, Yaxley, near Peterborough. (P. 172.)
13, 14.	„ „	var. *Siddingtonensis*. Cornbrash, Siddington, near Cirencester. (P. 172.)
15, 16.	„ „	var. *sub-obovata*, Walker. Cornbrash, Yaxley, near Peterborough. (P. 172.)
17—19.	„ „	var. *Stiltonensis*, Walker. Cornbrash, Stilton, near Peterborough. Collection of Mr. Walker. (P. 172.)
20.	„ „	var. *Stiltonensis*. Cornbrash, Scarborough. Leckenby Collection, Woodwardian Museum, Cambridge. (P. 172.)
21.	„ *digona*, Sow.	A specimen showing the loop. Great Oolite, Bath. Collection of author. (P. 173.)
22.	„ „	A specimen showing spines rising from the outer surface of the principal lamellæ or stems of the loop. 22 *a*. A portion of the lamella enlarged. Great Oolite, Bath. Collection of author. (P. 173.)
23.	„ *bucculenta*, Sow.	Lower Calcareous Grit, Malton, Yorkshire. Leckenby Collection, Woodwardian Museum, Cambridge. (P. 173.)



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SUPPLEMENT, PLATE XXIII.

Fig.

1—4. *Waldheimia Leckenbyi*, Walker, MS. Inferior Oolite, Leckhampton Hill, near Cheltenham. Collection of author. (P. 183.)

5—7. „ *emarginata*, Sow. 5, 6. Inferior Oolite, Broadwinsor. Collection of Mr. J. F. Walker. 7. A remarkably thickened example with very flat dorsal valve. Inferior Oolite, Bradford Abbas. Collection of Mr. D. Stephens. (P. 161.)

8. „ *Waltoni*, Dav. A remarkable example, with almost flat dorsal valve. Inferior Oolite, Broadwinsor. Collection of Mr. J. F. Walker. (P. 161.)

9, 10. „ „ A variety from the *R. cynocephala* or passage bed between the Upper Lias and Inferior Oolite proper, Haresfield, Gloucestershire. Collection of Mr. J. F. Walker. (P. 161.)

11. „ *florella*, d'Orb. *A. spinatus* zone, Middle Lias, Eston, Yorkshire. Collection of author. (P. 178.)

12, 13. „ „ var. *pyriformis*, Tate. Middle Lias. 12. Cleveland, Yorkshire. Collection of Mr. Walker. 13. Shales below Marlstone, Eston, Yorkshire. Collection of Professor Tate. (P. 178.)

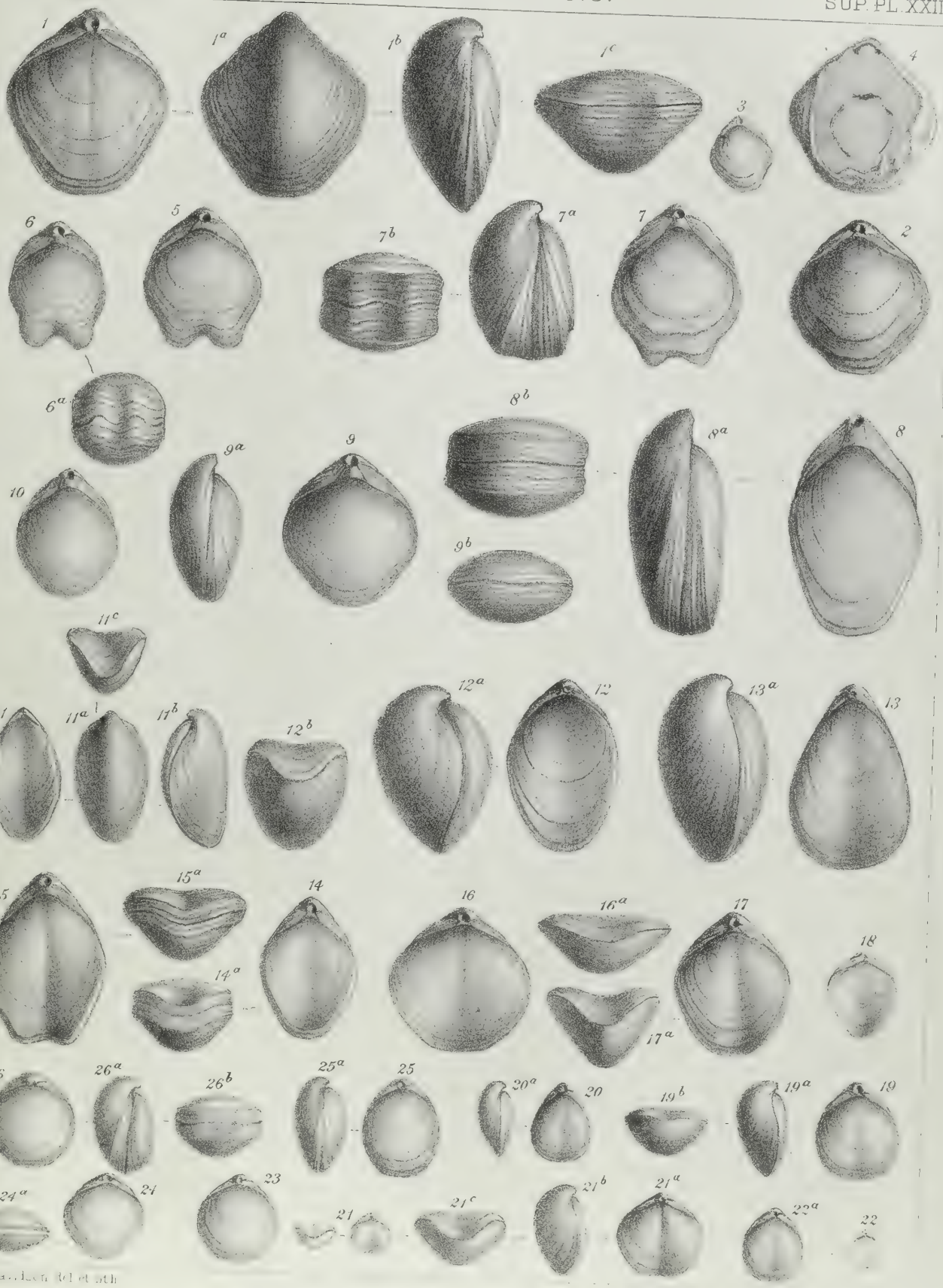
14, 15. „ *carinata*, Sow. 14. Inferior Oolite, Bradford Abbas. 15. Broadwinsor. Collection of Professor Buckman. (P. 179.)

16—18. „ „ var. *Mandelslohi*, Oppel (= *T. alveata*, Quenstedt). 16. Inferior Oolite, Bradford Abbas. Collection of Professor Buckman. 17. Lower Trigonia Grit (Inferior Oolite), Leckhampton Hill. Collection of Mr. Walker. 18. Inferior Oolite, Crickley Hill, near Cheltenham. Collection of Mr. Walker. (P. 180.)

19, 20. „ „ var. *Blakei*, Walker. From blocks of Shelly Dogger (Inferior Oolite) belonging to the Yellow Sands, Cliffs near Scarborough, Yorkshire. Collection of author. (P. 181.)

21, 22. „ „ small var. of *Mandelslohi?* Not found larger than fig. 21. Inferior Oolite, Bradford Abbas. Collections of Mr. D. Stephens and Mr. J. F. Walker. (P. 181.)

23—26. „ *anglica*, Oppel. Inferior Oolite from Bradford Abbas and Crewkerne Station, near Sherborne, Dorsetshire. Collection of Mr. D. Stephens. (Pp. 135 and 186.)



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SUPPLEMENT, PLATE XXIV.

Fig.			
1—4.	*Waldheimia perforata*,	Piette.	1. Lower Lias, Robin Hood Bay, Yorkshire. Collection of Mr. Walker. 2. Lower Lias, zone of *Am. angulatus*, Charmouth, near Lyme Regis. 3. = *T. ornithocephala*, Sow. From the original example in British Museum ('Min. Con.,' tab. 101, fig. 4). Blue Lias, Pickeridge. 4. A specimen showing long loop, after E. Deslongchamps, 'Brach. Pal. Brac. Jur.,' pl. xxiii, fig. 1. (P. 164.)
5.	„	?	Middle Lias, Bugbrook, near Weedon, Northamptonshire. Collection of Mr. Walker. (P. 164.)
6—8.	„	*Dorsetensis*,	Walker. Supra-Coralline, Abbotsbury, Dorsetshire. Collection of Mr. Walker. (P. 176.)
9—11.	„	*Darwini*,	E. Desl. Middle Lias, Clandown Quarries, Radstock. Collection of author. (P. 163)
12, 13.	„	*margaritata*,	Oppel. 12. Coral Rag, Farringdon. Collection of Mr. J. F. Walker. 13. Coral Rag, Calne. (P. 176.)
14, 15.	„	*Cadomensis*,	E. Desl. Young example. Inferior Oolite, near Bath. (P. 170.)
16, 17.	„	?	Inferior Oolite, Bradford Abbas. Collection of Mr. D. Stephens.
18, 19.	„	*humeralis*,	Roemer. Upper Oolite, Garty, Sutherlandshire. Collection of author. (P. 183.)
20.	„	sp. ?	An internal cast, showing an unusually long median septum or slit caused by it. Species not known. Coralline Oolite, zone of *Am. perarmatus* (Lower Calcareous Grit), Bramberry Hill, Sutherlandshir . Collection of author. (P. 185.)
21.	„	*cardium*,	var. *Leckhamptonensis*, Walker. Inferior Oolite (?), Andoversford. Museum of School of Mines, London. (P. 185.)
22.	„	„	Forest Marble, Islip, near Oxford. Collection of Mr. J. Parker. (P. 185.)
23.	„	*bucculenta*,	Sow. Elsworth Rock (Oxford Clay Series), Elsworth. Woodwardian Museum, Cambridge. (P. 173.)
24.	„	„	Passage beds, Lower Calcareous Grit, Appleton, near Malton, Yorkshire. Collection of Mr. J. F. Walker. (P. 173.)
25.	„	?	Cornbrash, Scarborough, Yorkshire. Leckenby Collection. Woodwardian Museum, Cambridge. (P. 173.)
26.	„	*bucculenta.*	Lower Calcareous Grit, Filey, Yorkshire. Collection of Mr. Walker. (P. 173.)
27.	„	*ornithocephala*,	Sow. A very large specimen. Fuller's Earth, Burton, Somersetshire. Collection of Mr. Walker. (P. 167.)
28, 29.	„	„	var. *Kellowayensis*, Etheridge, MS. Kelloway Loch, Kelloway. Museum of School of Mines, London.
30, 31.	„	*Lycetti*,	Dav. Upper Lias, Bloxham, near Banbury, Oxfordshire. Collection of Mr. James Griffin. (P. 175.)
32.	„	*impressa*,	V. Buch. Oxford Clay, Oxford Castle. Oxford Museum. (P. 182.)
33.	„	*curvifrons*,	Oppel. A fine example. Oolitic Marl (Inferior Oolite), Leckhampton Hill. Collection of Mr. J. F. Walker. (P. 153.)
34.	?	sp. ?	Middle Lias (Marlstone), Thorp, Satchwell, Leicester. Collection of Mr. J. Harrison.

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SUPPLEMENT, PLATE XXV.

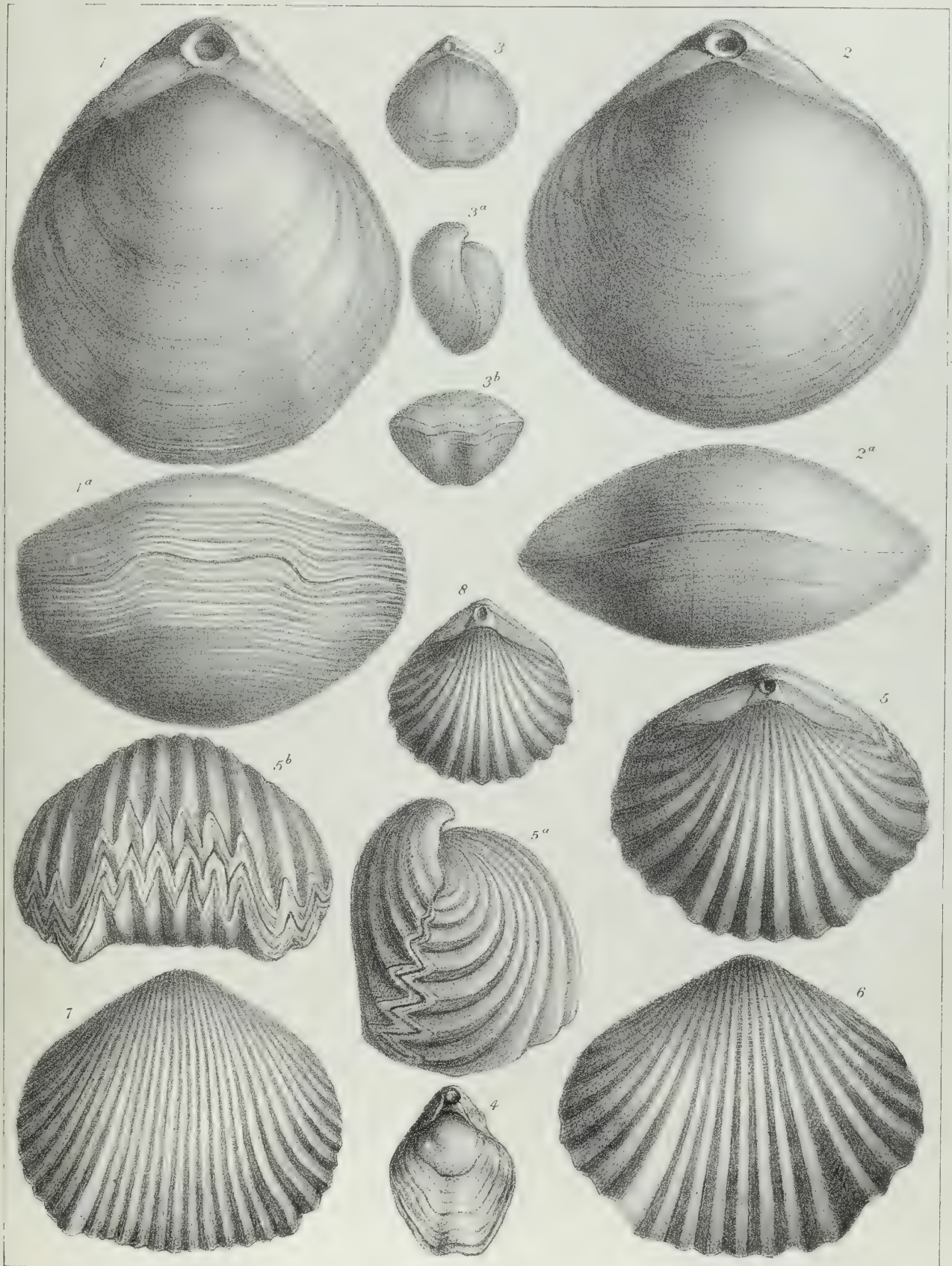
Fig.

1, 2. *Terebratula perovalis*, Sow., var. *ampla*, Buckman. Inferior Oolite, Bradford Abbas, Dorsetshire. Collection of Professor Buckman. (P. 122 and 156.)

3. „ *reticulata*, Sow. Fuller's Earth, Whatley, near Frome. Collection of Mr. J. F. Walker. A very fine example. (P. 144.)

4. „ *Bentleyi*, Dav. An elongated specimen. Cornbrash, Stilton, near Peterborough. Collection of Mr. J. F. Walker. (P. 141.)

5—8. *Rhynchonella Sutherlandi*, Dav. Upper Oolite (Supra-Coralline ?), Dunrobin, Sutherland. 5—7. Dunrobin Museum. These and the *Ter. perovalis*, var. *ampla*, are the largest British Jurassic Brachiopoda with which I am acquainted. Dunrobin Museum. (P. 190.)



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SUPPLEMENT, PLATE XXVI.

Fig.

1, 2. *Rhynchonella inconstans*, Sow. Young and adult. Typical form. 1. Kimmeridge Clay, Weymouth. 2. Kimmeridge Clay, Wootton Basset. Collection of Mr. Walker. (P. 191.)

3—6. „ „ var. with fewer plaits. 3. A symmetrical specimen, the mesial fold occupying the central lobe of the shell. Kimmeridge Clay, Wootton Basset. 4, 5. Unsymmetrical examples with a few large ribs. 4. Wootton Basset; 5, Shotover Hill, Oxford. Collection of Mr. J. Parker. 6. A young, flattened example from same locality and collection. (P. 191.)

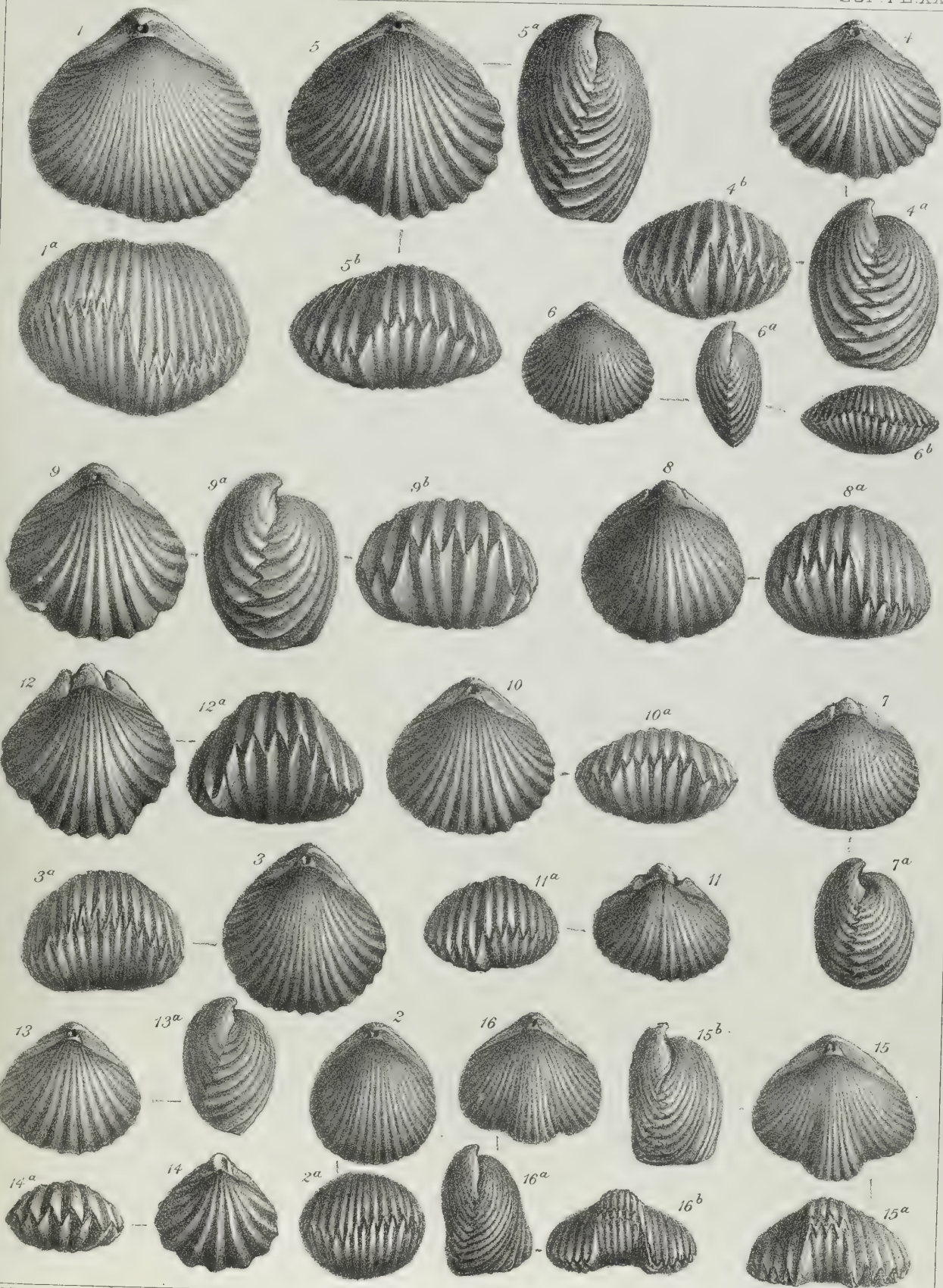
7. „ *pinguis*, Roemer (?). A specimen apparently agreeing with Roemer's figures. Supra-Coralline, Abbotsbury, Dorsetshire. Collection of Mr. Hudleston. (P. 193.)

8—12. „ „ var. *pectunculoides*, Étalon. A series of specimens showing some of its principal modifications in shape. Supra-Coralline, Abbotsbury, Dorsetshire. 8, 9. From Collection of Mr. Hudleston. 10, 11, 12. From that of Mr. J. F. Walker. (P. 194.)

13, 14. „ *lacunosa*, Schl. (?). 13. Lower Calcareous Grit, Beedall, Wykham. Museum of School of Mines, London. 14. Oliver's Mount, Yorkshire. Collection of Mr. Hudleston. (P. 196.)

15. „ *Boueti*, Dav. Cornbrash, Langton Herring, near Weymouth. Collection of Mr. J. F. Walker. (P. 197.)

16 „ „ From Bradford Clay, or Forest Marble, Burtonbradstock, north-east of Bridport, in Dorsetshire. Collection of Mr. D. Stephens. (P. 197.)



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SUPPLEMENT, PLATE XXVII.

FIG.

1—3. *Rhynchonella furcillata*, Theodori. Marlstone, Middle Lias, near Stephon Gorge. Museum of School of Mines. These are remarkable specimens on account of their very transverse shape. (P. 189.)

4—7. „ *plicatella*, Sow. 4. Inferior Oolite, Crewkerne Station, near Bradford Abbas, Dorsetshire. Collection of Mr. D. Stephens. 5, 6, 7. Young ages of the same. (P. 190.)

8, 9. „ ? *Lopensis*, Moore. After figure in the 'Proceedings of the Somersetshire Archæological and Nat. Hist. Soc.' From a blue Oolitic Marl (Inferior Oolite), Lopen, near Ilminster. (It is not a Rhynchonella, but I cannot from want of material determine its genus.) It is figured here for reference. Collection of Mr. C. Moore. (P. 217.)

10. „ *rimosa*, V. Buch. Inferior Oolitic Sands, Haresfield. This is the specimen that was mistaken by Mr. Lycett for *Rh. Jurensis*. Museum of School of Mines, London. (P. 189.)

11, 12. „ *capitulata*, Tate. Zone of *Am. spinatus*, Middle Lias, Eston, Yorkshire. 11. Natural size. 11 *a*, *b*, *c*, and 12 *a*. Enlarged. (P. 222.)

13. „ ? *coronata*, Moore. Upper Lias, Ilminster. 13 *a*, *b*, *c*. Enlarged. It is probably the fry of some other species. It is reproduced for reference. (P. 218.)

14, 15. „ *ringens*, Herault. Inferior Oolite, Half-way House, near Bradford Abbas, and where the shell is abundant. (P. 204.)

16. „ „ A variety from Inferior Oolite, near Sherborne. Collection of Mr. D. Stephens. 16 *a*. Enlarged. (P. 204.)

17. „ *Crossi*, Walker. Inferior Oolite, Appleby Brig, Lincolnshire. 17 *a*, *b*. Enlarged. Collection of Mr. J. F. Walker. (P. 223.)

18, 19. „ *spinosa*, var. *Bradfordiensis*, Walker. Bradford Clay. 18. Titbury Road Station. 19. Bradford, Wiltshire. Collection of Mr. J. F. Walker. (P. 222.)

20. „ *Stephensi*, Dav. Inferior Oolite, Crewkerne Station, Dorsetshire. 20 *a*, *b*. Enlarged. Collection of Mr. D. Stephens. (P. 220.)

21. „ *parvula*, E. Desl. Inferior Oolite, Bradford Abbas. 21 *a*, *b*, *c*. Enlarged. Collection of Author. (P. 219.)

22. „ *concinna*, Sow. Cornbrash, Yaxley, near Peterborough. Collection of Author. (P. 205.)

23. „ var. *Yaxleyensis*. Same formation and locality. (P. 206.)

24—27. „ *Jurensis*, Quenstedt. Upper Lias zone of *Am. communis*, Railway Station, Bloxham, near Banbury. Collection of Author. (P. 224.)

Thos Davidson del. et lith.

Hanhart imp

SUPPLEMENT, PLATE XXVIII.

FIG.

1—3. *Rhynchonella varians*, var. *Smithii*, Walker. 1. Fuller's Earth, near Bath. 2. Fuller's Earth Rock, Whatley Church, Frome. 3. Fuller's Earth, Crammon, Somerset. Collection of Author. (P. 213.)

3A, 3B. ,, ,, Schloth. Kelloway Rock, Scarborough. Collection of Author. (P. 212.)

4. ,, ,, Oxford Clay, Oxford Castle. Oxford Museum. (P. 212.)

5—7. ,, ,, var. *spathica*, Lam. Oxford Clay. 5. St. Clement's, Oxford Museum. 6, 7. St. Clement's and Somertown, near Oxford. Collection of Mr. J. Parker. (P. 214.)

8—11. ,, ,, var. *socialis*, Phillips. Kelloway Rock, Scarborough Castle. 8. After Phillips, 'Geol. York,' pl. vi, fig. 8. 9. Profile view of a larger example. 10, 11. Usual size. (P. 214.)

12. ,, ,, After the original figure of *T. varians* referred to by Schlotheim, 'Encycl. Meth.,' pl. 241, fig. 5 *a*, *b*. (P. 212.)

13. ,, ,, Lower Calcareous Grit, Filey, Yorkshire coast. (P. 212.)

14—16. ,, ,, var. *Thurmani*, Volts. 14. A large specimen. Lower Calcareous Grit, Castle Howard, Yorkshire. Collection of Mr. J. F. Walker. 15. Lower Calcareous Grit, Filey, Yorkshire. 16. Another specimen, passing into *R. Leedsii*. (P. 215.)

17. ,, *Leedsii*, Walker. Cornbrash, Scarborough. Leckenby Collection, Woodwardian Museum, Cambridge. (P. 216.)

18, 19. ,, *Amalthei*, Quenstedt. 18. Middle Lias, zone of *Am. spinatus*, Thenford, near Banbury. Collection of Mr. E. W. Walford. 19. Middle Lias, South Petherton, near Ilminster. Collection of Mr. E. W. Walford. (P. 201.)

20. ,, ? var. A. *Am. communis* zone, Upper Lias, Churchdown, Somerset (Smithe). Collection of Author. (P. 201.)

21. ,, ? var. B. *A. margaritatus* zone, Middle Lias, Churchdown, Somerset. (P. 201.)

22. ,, *Glevensis*, Smithe, MS. *Am. angulatus* zone, Lower Lias, Churchdown. Collection of Author. (P. 221.)

23. ,, *egretta*, E. Desl. Middle Lias, Chideock. Museum of School of Mines, London. (P. 216.)

24—32. ,, *calcicosta*, Quenstedt. Different variations in shape from Lower Lias of Churchdown and Stonehouse. 25. From Middle Lias, Huntcliff, Yorkshire. Collection of Professor Tate. 31, 32. Zone of *Am. margaritatus*, Middle Lias, Undercliff, Yorkshire. (P. 220.)

33. ,, ,, After Quenstedt. Original figure in 'Handbuch,' tab. xxxvi, figs. 6, 7. (P. 221.)

34. ,, *plicatissima*, Quenstedt. After Quenstedt's figure, 'Handbuch,' pl. xxxvi, fig. 3, given here for comparison and reference. (P. 221.)

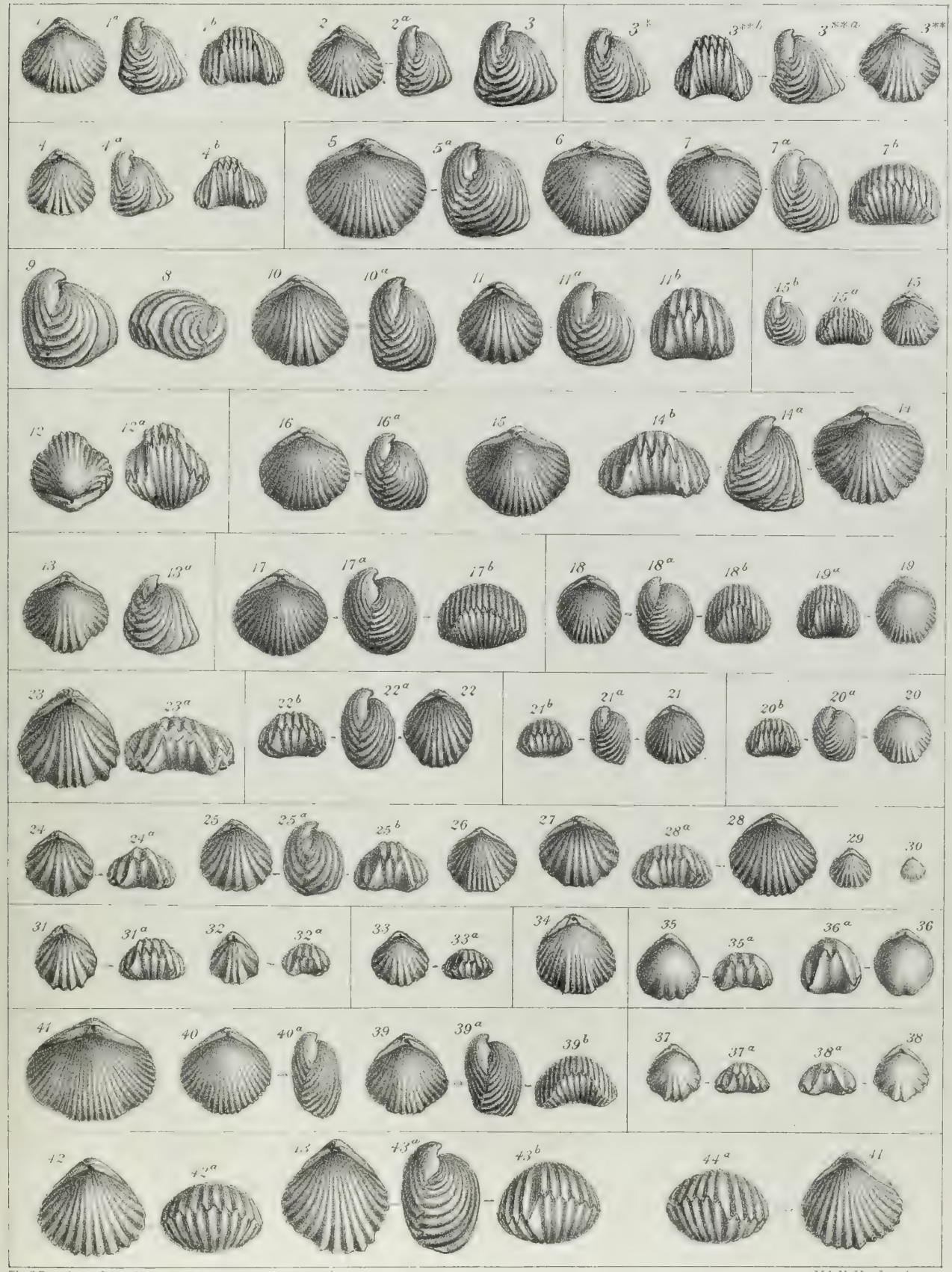
35, 36. ,, *triplicosa*, var. *juvenis*, Quenst. These specimens agree exactly with those figured by Quenstedt. Lower Lias, Stonehouse. (P. 211.)

37, 38. ,, *oxynoti*, Quenstedt. Lower Lias, Aston cutting. These agree with the German types. (P. 210.)

39—41. ,, *fodinalis*, Tate. 39, 40. Middle Lias, Eston, Yorkshire. Tate's figured types. 41. A large, fine example from Middle Lias zone of *Am. spinatus*, King's Sutton, near Banbury. Collection of Mr. Beesley. (P. 206.)

42—44. ,, *sub-obsoleta*, Dav. Oolitic Marl (Inferior Oolite), Cleeve Hill, Cheltenham. Collection of Professor R. Tate. (P. 207.)

45. ,, *Tatei*, Dav. Oolitic Marl (Inferior Oolite), Seven Springs, Cubberfield, south side of Ravensgale Hall, Cheltenham. (P. 218.)



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SUPPLEMENT, PLATE XXIX.

Fig.

1—3. *Rhynchonella quadriplicata*, Zieten. Oyster Bed, Inferior Oolite, Cleave Hill, near Cheltenham. Collection of Mr. J. F. Walker. (P. 201.)

4. „ *obsoleta*, Sow. Inferior Oolite, Crewkerne Station. Collection of Mr. D. Stephens. (P. 207.)

5. „ *tetrahedra*, var. *Dumbletonensis*, Dav. Middle Lias, Dumbleton, near Cheltenham. Collection of Author. (P. 199.)

6. „ „ Marstone, Middle Lias, Churchdown. (P. 198.)

7—12. „ „ var. *Northamptonensis*, Walker. Marlstone, Middle Lias, Bugbrook, near Weedon, Northamptonshire. Collection of Mr. J. F. Walker. (P. 199.)

13. „ *sub-decorata*, var.? Seems intermediate between *Rh. sub-decorata* and *Rh. sub-tetrahedra*. Collection of Mr. J. F. Walker. (P. 201.)

14—16. „ *sub-angulata*, Dav. Inferior Oolite, Cleeve Hill, near Cheltenham. Collection of Mr. Walker. 15. From Pea Grit, Inferior Oolite, Leckhampton Hill. Same Collection. 16. Profile view of a specimen from Inferior Oolite, Bradford Abbas, Dorsetshire. Collection of Author. (P. 208.)

17, 18. „ *lineata*, Young and Bird. 17. Shaly Ironstone, called Cockle Band, zone of *Am. spinatus*, Middle Lias, Eston, Yorkshire. 18. Internal cast of part of the beaks, showing the denticulated sockets. Middle Lias, Skinning Grove, Yorkshire. Collection of Author. (P. 209.)

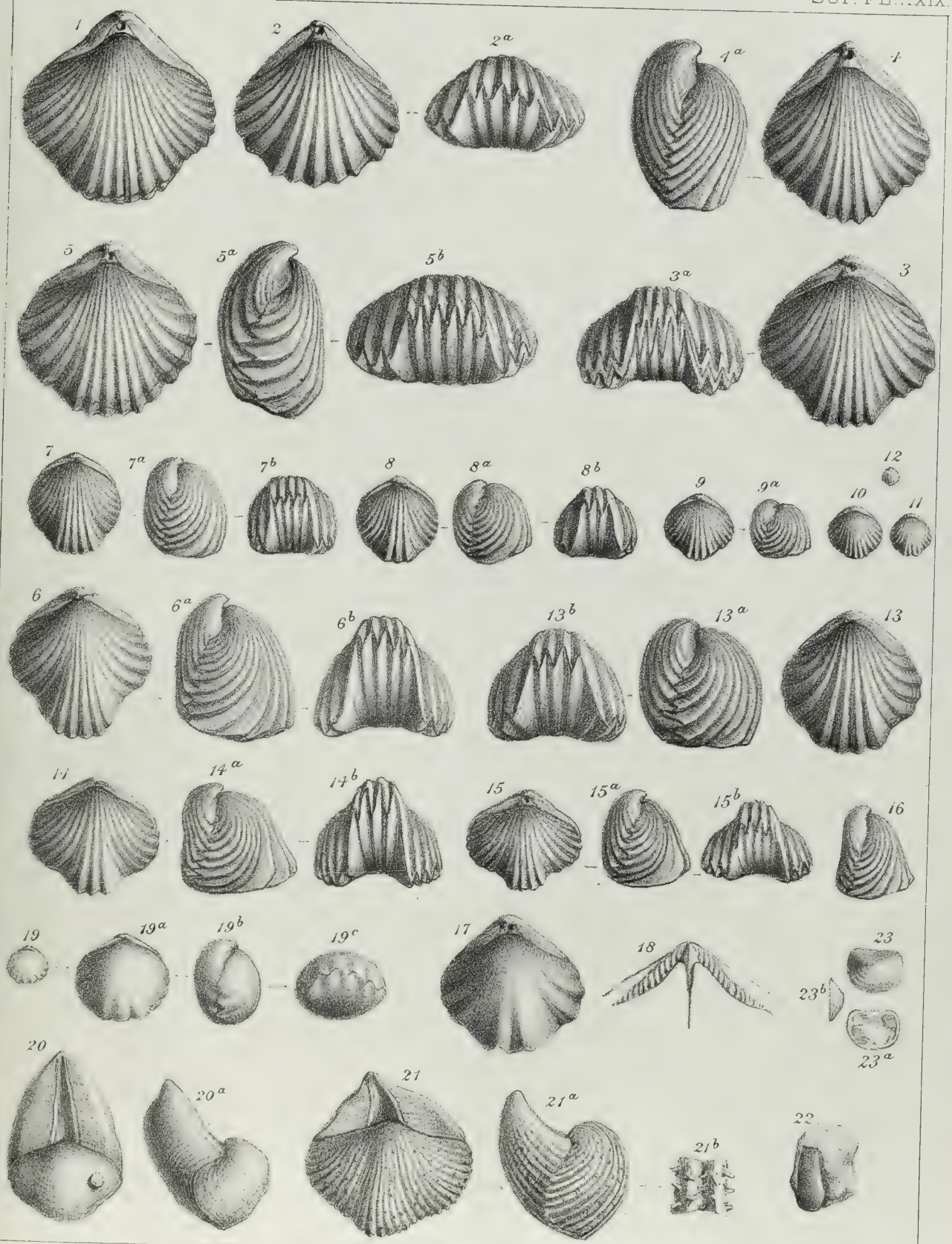
19. „ *Bouchardii*, Dav. (?) Young age. Upper Lias, Barrington, near Ilminster. Collection of Mr. J. F. Walker. (P. 205.)

20. *Spiriferina adscendens*, E. Desl. Middle Lias, Chideock. Museum of Bridport Institution; attached to it is a specimen of *Thecidium Moorei*. (P. 227.)

21. „ *Tessoni*, var.? Same formation, locality, and museum. (P. 228.)

22. *Lingula ovalis*? From the junction bed between Coral Rag and Kimmeridge Clay, Ringstead Bay, near Weymouth. Collection of Rev. P. B. Brodie. (P. 226.)

23. *Crania Griffini*, Dav. *Am. spinatus* zone, Middle Lias, King's Sutton, near Banbury. Collection of Mr. Innes Griffin. (P. 226.)



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MONOGRAPH

ON THE

LIAS AMMONITES

OF

THE BRITISH ISLANDS.

BY

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PART FIRST.—THE LIAS FORMATION.

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THE LIAS AMMONITES

OF THE

BRITISH ISLANDS.

Before describing the Ammonitidæ of the Lias I purpose giving a short account of the several zones of life into which this great formation is divided, with the view of defining their statigraphical distribution in time and space. More ample details on the subject will be found in the various works cited in the synonyms prefixed to the description of the different zones.

English geologists divide this formation into Upper Lias, Marlstone, and Lower Lias, but these subdivisions require additions and modifications in order to place the liassic beds of the British Isles in strict correlation with those of France, Switzerland, and Germany. For on the Upper Lias clays, in certain localities, are superimposed extensive arenaceous deposits, which, previous to the publication of my memoir on the Upper Lias Sands,[1] were grouped with the Inferior Oolite, and in the Lower Lias are included several beds of clays and marls which, with the Marlstone of English authors, form the Middle Lias of Continental geologists.

Taking the Lias beds so well exposed in their natural order of superposition in the north and south of England in the magnificent sections on the Yorkshire and Dorsetshire coasts, and naming each group of beds by the most characteristic Ammonite form contained therein, we find the following zones of life, taken in descending order:

The Upper Lias.—The sands[2] forming the upper portion of this zone, are characterised for the most part by Ammonites belonging to the groups Harpoceras and Lytoceras, as *Harpoceras opalinum*, Rein., *H. radians*, Schloth., *H. Thouarsense*, d'Orb.,

[1] "Palæontographical and Stratigraphical Relations of the so-called 'Sands of the Inferior Oolite,'" 'Quart. Journ. of the Geological Society,' vol. xii, p. 292, 1856.

[2] Midford Sands, so named by the late Professor Phillips in his 'Geology of Oxford and the Thames Valley,' p. 118, 1871.

H. insigne, Schübl., with *Lytoceras jurense*, Ziet., *L. hircinum*, Schlüb. The clays forming the lower part of the zone are everywhere distinguished by *Harpoceras bifrons*, Brug., *H. serpentinum*, Schloth., and numbers of the group *Stephanoceras*, as *Steph. commune*, Sow., *S. anguinum*, Rein., and *S. fibulatum*, Sow.

The Middle Lias.—This is divisible into five zones, each characterised in descending order by—1. *Amaltheus spinatus*, Brug. 2. *A. margaritatus*, Mont. 3. *Aegoceras Henleyi*, Sow. 4. *Amaltheus Ibex*, Quenst. 5. *Aegoceras Jamesoni*, Sow.

The Lower Lias is divisible into seven zones. These are—1. Zone of *Arietites raricostatus*, Ziet. 2. *Amaltheus oxynotus*, Quenst. 3. *Arietites obtusus*, Sow. 4. *A. Turneri*, Sow. 5. *A. Bucklandi*, Sow. 6. *Aegoceras angulatum*, Schloth. 7. *Aegoceras planorbis*, Sow., reposing comformably on the *Avicula contorta* series.

Complicated as these subdivisions may at first sight appear to those who have been accustomed to regard the Lias formation as a great clay deposit, with a uniform fauna throughout, still their accuracy may be clearly demonstrated in the extensive section on the Dorsetshire coast, extending from near Bridport Harbour on the east to Pinhay Bay on the west. For within these limits the entire series of beds rise beneath each other on the shore, and are exposed in the cliffs, so that this coast section may be said to be complete from the great arenaceous deposit of Upper Lias Sand, containing *Harpoceras opalinum*, with each succeeding zone of the Upper, Middle, and Lower Lias, down to *Aegoceras planorbis*, and its Ostrea series, resting on the *Avicula contorta* beds of the Trias formation.

In the following table I have placed the different zones of the English Lias in correlation with those of Germany, so well described by Professors Quenstedt, Oppel, Fraas, and others; those of France by the late M. A. d'Orbigny, and those of England by Sir R. Murchison, Sir H. De la Beche, and the Rev. W. D. Conybeare.

This table likewise shows how completely the whole Lias formation is represented in England, and how nearly it corresponds bed for bed with the Würtemberg series. I shall now describe the different zones in ascending order, commencing with the zone of *Avicula contorta*.

As much difference of opinion formerly prevailed regarding the true position of the Contorta zone, I have deemed it best to give a short account of the beds in question for the purpose of showing how distinct their lithological and palæontological characters are from those of the true Lias formation which rests upon them, and how necessary it is to clear away all doubts as to the true affinities of these beds before entering upon the study of the Lias formation which forms the subject of this introductory part of our Monograph.

A TABLE SHOWING THE CORRELATION OF THE LIAS BEDS OF FRANCE, GERMANY, AND ENGLAND.

SWABIA. *Quenstedt.*	WÜRTEMBERG. *Oppel.*	FRANCE. *d'Orbigny.*	SOUTH OF ENGLAND. *Wright.*	GLOUCESTERSHIRE. *Murchison.*	DORSETSHIRE. *De la Beche.*
Lias ξ. *Jurensismergel.*	Jurensis-bett.	*Toarcien.*	*Zone of* LYTOCERAS JURENSE.	Inferior Oolite.	Inferior Oolite.
Lias ε. *Posidonienschiefer.*	Posidonomyen-bett.	UPPER LIAS.	*Zone of* STEPHANOCERAS COMMUNE.	Upper Lias.	Lower part.
Lias δ. *Amaltheenthone*	Spinatus-bett.		*Zone of* AMALTHEUS SPINATUS.	Marlstone.	
	Margaritatus-bett.	*Liasien.*	*Zone of* AMALTHEUS MARGARITATUS.		Micaceous Marl.
Lias γ. *Numismalismergel*	Davœi-bett.		*Zone of* AEGOCERAS HENLEYI.		
	Ibex-bett.	MIDDLE LIAS.	*Zone of* AMALTHEUS IBEX.	Ochraceous Lias.	
	Jamesoni-bett.		*Zone of* AEGOCERAS JAMESONI.		Belemnite Bed. — Upper Marl.
Lias β. *Turnerithone*	Raricostatus-bett.		*Zone of* ARIETITES RARICOSTATUS.	Hippopodium & Cardinia Beds. — Lower Lias Shales.	
	Oxynotus-bett.		*Zone of* AMALTHEUS OXYNOTUS.		
	Obtusus-bett.	*Sinèmurien.*	*Zone of* ARIETITES OBTUSUS.	Ammonite Bed	Ammonites in nodules.
	Tuberculatus-bett.	LOWER LIAS.	*Zone of* ARIETITES TURNERI.		
Lias α. *Sand u. Thonkalke.*	Bucklandi-bett.		*Zone of* ARIETITES BUCKLANDI.	Plagiostoma Beds.	Lias Limestones. — Lower Lias Limestones.
	Angulatus-bett.		*Zone of* AEGOCERAS ANGULATUM.	Lower Lias Limestones and Shales.	
	Planorbis-bett.		*Zone of* AEGOCERAS PLANORBIS.	Saurian and Insect Beds.	White Lias, upper part. — White Lias.
Vorläufer des Lias.	Bone-bed.		*Zone of* AVICULA CONTORTA.	Black Shales and Bone Bed.	White Lias, inferior part. — White Lias.
					Lower Marl, Bone Bed.

The Zone of Avicula contorta.

Synonyms.—Von Buch, "Schicht mit Gervillien auf der Gruber Alp am Setzberge in den bayr. Alpen," Denksch. Akad. Wissensch. Berlin, Jahrg. p. 82, 1828. Alberti, "Versteinerungsreicher Sandstein von Täbingen," 1834. Strickland, "Calcareous Sandstone with Pectens, and White Micaceous Sandstone with Bivalve Shells." Proceedings of the Geological Society, vol. iii, p. 586, 1842. Portlock, "Shale" with *Avicula contorta* and "loose gritty marl" containing *Pecten Valoniensis*, Report on Geology of Londonderry, pp. 126, 127, 1843. Brodie, "Pecten-bed," Fossil Insects of the Secondary Rocks, p. 58, 1845. Quenstedt, "Gelbe Sandsteine," Flözgebirge Württembergs, 1846. Emmerich, "Gervillien-Schichten," Neues Jahrbuch, p. 437, 1849. Schafhäutl, "Schiefergebilde der Wetzsteinformation mit Gervillien," Geognost. Untersuch. südbayrischen Alpengebirges, 1851. Von Hauer, "Kössener-Schichten," Jahrbuch der k. k. geologischen Reichsanstalt, p. 733, 1853. Escher, "Oberes St.-Cassian.," Geologische Bemerkungen über Voralberg, 1853. Gümbel, Gervillien-(Kössener-)Schichten in der Grünten," Geognostische Skizze, 1856. Oppel and Suess, "Kössener-Schichten," Sitzungsber. Akadem. Wissenschaft. Wien, vol. xxi, p. 525, 1856. Oppel, "Kössener-Schichten," Jura, p. 290, 1856. Winkler, "Die Schichten der *Avicula contorta* inner- und ausserhalb der Alpen," 1859. Oppel, "Die Zone der *Avicula contorta*," Württemberg. natur. Jahreshefte, p. 315, 1859. Lyell, "Infra-liassic Strata of Austrian Alps," Supplement to the Manual of Geology, 5th ed., 1857. Suess, "Kössener-Schichten," Ueber die Brachiopoden, &c., 1854. Jules Martin, "Infra-Lias" (pars), Paléontologie stratigraphique de l'Infra-Lias du Département de la Côte-d'Or, Mém. Soc. Géol. France, 2 série, vol. vii, 1860. Stoppani, Essai sur les conditions générales des couches à *Avicula contorta*, 1861, supplement à l'essai 1863. Alphons v. Dittmar, Die Contorta-Zone ihre Verbreitung und ihre organischen Einschlüsse, 1864. Renevier, Notices géologiques et paléontologiques sur les Alpes Vaudoises, p. 1, 1864. Dumortier, "Infra-Lias, zone à *Avicula contorta*," Études Paléont. sur les Dépots Jurass. du Bassin du Rhône, tom. i, p. 6, 1864. Boyd Dawkins, "Rhætic Beds," Journ. Geol. Soc., vol. xx, p. 396, 1864. Das Rhät in der Umgegend v. Göttingen, L. Pflücker y Rico, Berlin, 1868. Brauns, Die untere Grenze des Jura und die ihr zunächst liegenden Triasschichten, p. 22, 1871. Tate and Blake, Yorkshire Lias, "The Rhætic Series and the relations of the Lias with the Keuper," p. 30, 1876.

The *Avicula contorta* beds, as proved by the above list of synonyms, have for forty years engaged the attention of geologists, who, after much discussion as to their true place in the series, are still divided in opinion as to whether they ought to be considered the upper portion of the Keuper or the basement-beds of the Lias. It is now generally admitted that the *facies* of the fauna of the *Avicula contorta* zone has more affinities with the Kössener-Schichten of the Tyrol and the Upper St.-Cassian beds of Germany than with the true Lias, and it can be demonstrated that most of the species of *Radiata, Mollusca,* and Fishes, found in the *Avicula contorta* beds, are special to them, and do not pass into the Lias.

The question where does the Lias formation commence is easier asked than answered, for between the uppermost beds of the grey marls of the Keuper and the lowest true beds of the Lias is a remarkable assemblage of strata, which I long ago described as the "AVICULA CONTORTA BEDS," from that shell forming their leading fossil. Typical sections of the Contorta series are exposed at Garden cliff, Aust cliff, Penarth, and Watchet on the Severn shores; at Weston, Keynsham, Willsbridge, and Salford, near Bath, and at Puriton, Uphill, and Wells in Somersetshire, as well as in many other localities. In the upper part of the series are dark-grey shales interstratified with bands of limestone containing *Avicula contorta*, *Cardium Rhæticum*, *Pecten Valoniensis*, and *Schizodus elongatus*; and in the lower part the Bone-bed, consisting of hard dark siliceous grit, charged with bones, spines, teeth, and scales of Fishes belonging to the genera *Nemacanthus*, *Acrodus*, *Sargodon*, *Hybodus*, and *Ceratodus*, with bones of Reptilia belonging to the genera *Ichthyosaurus* and *Plesiosaurus*, and the teeth of a small Mammal, *Microlestes antiquus*, Plieninger.

As no sketch of the Lias formation can be said to be complete without its relation to the Trias below and the Jurassic rocks above being clearly defined, I shall briefly describe some type sections of the *Avicula contorta* beds in which the relation of these to the base of the Lias is very well shown.

GARDEN CLIFF, NEAR WESTBURY-ON-SEVERN.

I made a detailed section of the *Avicula contorta* beds of Garden Cliff, near Westbury-on-Severn, many years ago,[1] as it affords one of the most typical profiles of the zone known to me, and that best situated for study, and I recommend its careful examination to all who wish to know this series, as each stratum emerges in succession by the river bank, and can be measured and searched for its fossils, as it rises in the cliff at a low angle. The Rev. W. D. Conybeare[2] gave a section of this, which he called "Westbury Cliff, on the west bank of the Severn," for the purpose of illustrating the lower beds of the Lias formation, which reads as follows:—

	Ft.	In.
White Lias	10	0
Blue shale passing into Marlstone	10	0
Black shale with iron-shot fissures	12	0
Green siliceous grit, highly micaceous, and containing abundant bones, well known here and at Aust by the name of the Bone-bed	1	0
Black shale	2	0
Green grit	0	6
Black shale	2	0
Greenish Marlstone decomposing into balls	18	0
Red marl of the new red sandstone formation	0	0

[1] 'Quart. Jour. Geol. Soc.,' vol. xvi, p. 378, 1860.

[2] 'Geology of England and Wales,' p. 263, 1822.

The outline of the above agrees in some respects with my section, but the naming of the beds and the absence of their fauna, renders it valueless for the purpose of correlation with the many other exposures of strata of the same age throughout Europe.

The cliff should be reached about ebb-tide, as this will afford ample time for examining all the beds as they rise from the shore line. The *Estheria*-bed[1] must be diligently searched for its special Crustacea. The *Contorta* shales and *Cardium* shales contain an immense number of small shells, much compressed; and it will be necessary for the student to carry with him a thin solution of gum arabic and a hair pencil, so as to give the fossiliferous slabs he extracts a coating of the solution whilst the shells are *in situ*, and allow them to dry in the sunshine, otherwise he will fail to preserve the treasures he gathers from these brittle paper-like strata.

Detailed Section of Garden Cliff.

No.	Lithology.	Thickness.	Palæontology.
		ft. in.	
1	Brown or grey hard limestone with numerous shells	0 4	*Modiola minima, Ostrea liassica, Protocardium, Pleuromya.*
2	Thin brown shales containing Fishes' scales and teeth	2 0	Fish remains, scales, and teeth; genera indeterminable.
3	Cream-coloured fissile argillaceous limestone, the *Monotis-bed*	0 4	*Monotis decussata, Anatina præcursor, Myacites musculoides, Gervillia præcursor.*
4	Indurated brown marls, clayey and shaly in parts	3 6	Fishes' teeth and scales are seen on the split laminæ.
5	Grey fissile marls, with thin pyritic limestone bands	3 0	Fossils in the limestone bands, but indeterminable as to species.
6	Light grey, nodular, marly limestone, *Estheria-bed*	1 0	*Estheria minuta*, var. *Brodieana*, Jones, found in nests in the hard limestone.
7	Chocolate-coloured shales, laminated and friable, containing many seams of compressed shells, which must be examined when exposed	7 0	*Avicula contorta, Pecten Valoniensis, Cardium Rhæticum, Axinus cloacina, Lima præcursor, Neoschizodus posterus, Pleurophorus, Myacites, Modiola*, and Gasteropods indeterminable.
8	Dark shaly clay with many seams of compressed shells, and two indurated bands containing Pectens	2 0	*Pecten Valoniensis* forms an upper Pecten-bed. *Pullastra arenicola, Axinus, Cardium Rhæticum*, and *Pecten Val.* Lower *Pecten*-bed.
9	Dark grey *contorta shales* with seams of shells	2 6	*Avicula contorta* compressed with *Axinus, Cardium, Pecten*, &c.
10	Dark brown paper-like Cardium-shales with many seams of shells	7 0	*Cardium Rhæticum* in great numbers, *Pecten Valoniensis, Axinus, Ophiolepis Damesii.*
11	*Bone-bed* calcareo-siliceous pyritic band forming an osseous breccia in parts with a clay bed between	1 0 0 6 0 1	*Acrodus minimus, Nemacanthus filifer, Hybodus minor, Gyrolepis tenuistriatus, Saurichthys apicalis, Sargodon tomicus, Avicula, Axinus, Pullastra.*
12	Black shales	1 6	Non-fossiliferous.
13	Dark grey, micaceous, ripple-marked sandstone, forming ledges; the *Pullastra bed*	1 0	*Avicula contorta, Cardium Rhæticum, Pullastra arenicola, Modiola minima.* Fishes' teeth.
14	Dark shales	1 10	Non-fossiliferous.
15	*Lower Bone bed*, dark and gritty sandstone, with teeth	0 4	*Acrodus, Sargodon, Gyrolepis, Avicula contorta, Pullastra arenicola.*
16	Dark laminated shales	1 4	Teeth, scales, coprolites, &c., at base.
17	Grey marls of Keuper		Unfossiliferous.

[1] Rupert Jones' 'Monogr. Foss. Estheriæ,' Pal. Soc. vol. for year 1860, p. 70, &c.

FIG. 1.—*A Vertical Profile of Garden Cliff.*

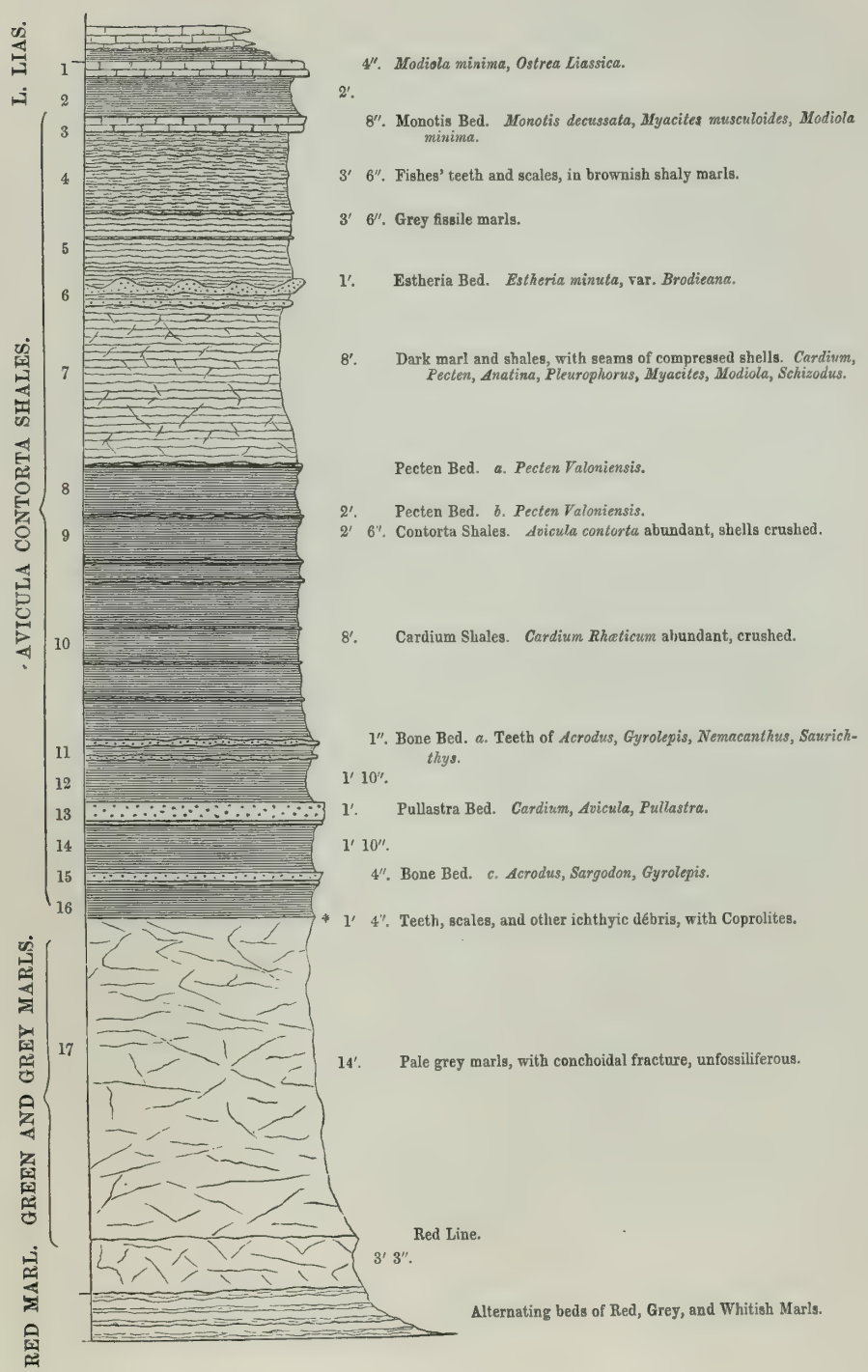
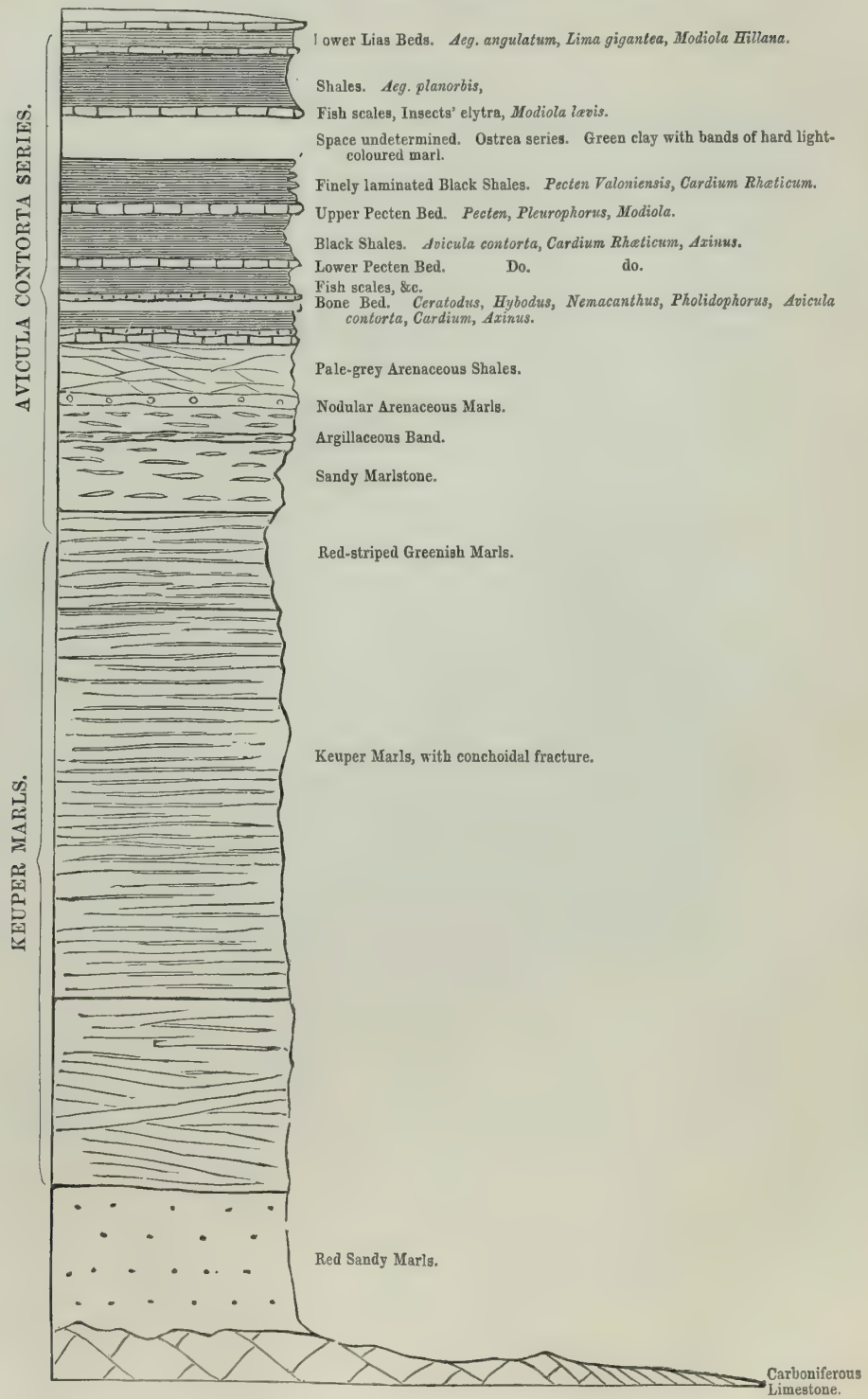

L. LIAS.
AVICULA CONTORTA SHALES.
RED MARL. GREEN AND GREY MARLS.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
4″. *Modiola minima, Ostrea Liassica.*
2′.
8″. Monotis Bed. *Monotis decussata, Myacites musculoides, Modiola minima.*
3′ 6″. Fishes' teeth and scales, in brownish shaly marls.
3′ 6″. Grey fissile marls.
1′. Estheria Bed. *Estheria minuta,* var. *Brodieana.*
8′. Dark marl and shales, with seams of compressed shells. *Cardium, Pecten, Anatina, Pleurophorus, Myacites, Modiola, Schizodus.*
Pecten Bed. *a. Pecten Valoniensis.*
2′. Pecten Bed. *b. Pecten Valoniensis.*
2′ 6″. Contorta Shales. *Avicula contorta* abundant, shells crushed.
8′. Cardium Shales. *Cardium Rhæticum* abundant, crushed.
1″. Bone Bed. *a.* Teeth of *Acrodus, Gyrolepis, Nemacanthus, Saurichthys.*
1′ 10″.
1′. Pullastra Bed. *Cardium, Avicula, Pullastra.*
1′ 10″.
4″. Bone Bed. *c. Acrodus, Sargodon, Gyrolepis.*
1′ 4″. Teeth, scales, and other ichthyic débris, with Coprolites.
14′. Pale grey marls, with conchoidal fracture, unfossiliferous.
Red Line.
3′ 3″.
Alternating beds of Red, Grey, and Whitish Marls.

FIG. 2.—*A Vertical Profile of Aust Cliff.*


AVICULA CONTORTA SERIES.
KEUPER MARLS.
Lower Lias Beds. *Aeg. angulatum, Lima gigantea, Modiola Hillana.*
Shales. *Aeg. planorbis,*
Fish scales, Insects' elytra, *Modiola lævis.*
Space undetermined. Ostrea series. Green clay with bands of hard light-coloured marl.
Finely laminated Black Shales. *Pecten Valoniensis, Cardium Rhæticum.*
Upper Pecten Bed. *Pecten, Pleurophorus, Modiola.*
Black Shales. *Avicula contorta, Cardium Rhæticum, Axinus.*
Lower Pecten Bed. Do. do.
Fish scales, &c.
Bone Bed. *Ceratodus, Hybodus, Nemacanthus, Pholidophorus, Avicula contorta, Cardium, Axinus.*
Pale-grey Arenaceous Shales.
Nodular Arenaceous Marls.
Argillaceous Band.
Sandy Marlstone.
Red-striped Greenish Marls.
Keuper Marls, with conchoidal fracture.
Red Sandy Marls.
Carboniferous Limestone.

Figs. 1 and 2 were drawn by my friend Robert Etheridge, Esq., F.R.S., to illustrate papers published in the 'Trans. of the Cotteswold Naturalists' Field Club;' he has kindly allowed me to use them here; and my friend Dr. Paine, F.C.P., Hon. Secretary to the Society, has given me the use of the woodcuts. To both old friends I return my best thanks.

Aust Cliff.

If we proceed from Garden Cliff down the Severn, the next section of the *Avicula contorta* beds is met with at Aust Cliff, so long famous for its Bone-bed and the large number of *Ceratodus* teeth which from time to time have been collected therefrom.

My old friend, the late Mr. Willliam Sanders, F.R.S., of Bristol, many years ago carefully measured this section, a matter of much difficulty from the mural character of the escarpment, and the result of his labours was published by Sir Henry De la Beche, in his valuable memoir on the geology of the South-west of England,[1] Buckland and Conybeare having previously published a section of the cliff in their memoir on the south-western coal-district of England.[2]

In the upper part of the section are found about three feet of grey argillaceous Lias Limestone, containing *Aegoceras angulatum*, Schloth., *Lima gigantea*, Sow., *Lima antiquata*, Sow., and *Modiola Hillana*, Sow., representing the lower beds of the Lima-series. Below these are nine beds consisting of grey marls and argillaceous limestone representing the zone of *Aegoceras planorbis*. The lowest limestone bed of the series contains scales of Fishes, elytra of Insects, with *Modiola minima* and *Terebratulæ*; this rests upon eight feet of grey, light-coloured marls, with nodular limestone, the equivalent of the Ostrea-beds and White Lias series, of the strata numbered two to six inclusive in the detailed section of Garden Cliff (p. 6). The Cotham Marble caps the marly beds, and this well-known singular band forms the base of the Ostrea-series. The gap in the section is intended to represent a space of thirteen feet which could not be satisfactorily examined. Below this space five feet of thinly laminated black shales are exposed, and beneath is a five-inch band of hard grey limestone, containing scales of Fish, *Pecten Valoniensis*, *Placunopsis alpina*, *Pleurophorus elongatus*, representing the upper Pecten bed of the Garden Cliff section, &c.; this band rests upon another bed of black shales, eight feet in thickness, containing seams of shells. Here are found *Avicula contorta*, *Cardium Rhæticum*, *Pullastra arenicola*, *Axinus*, *Anomia*, &c. The fossils are very numerous, but much compressed, and determined with difficulty. The Contorta-shales rest upon a second or lower Pecten-bed, consisting of a hard grey shelly limestone, eight inches thick, containing *Avicula contorta*, *Cardium Rhæticum*, *Pullastra*, *Axinus*, *Anomia*, &c., in fact all the same shells that are found in the black shales above. Beneath the limestone band is another bed of black shales, four feet thick, intersected by thin, inconstant, indurated bands, containing Fishes' scales, &c. The shales rest upon the true Bone-bed, which is here a most remarkable band of dark-grey, crystalline, calcareo-siliceous rock, containing nodules of marl, masses of dark coprolitic matter, bones of Saurians, teeth of Ceratodus and other Fishes, in fine preservation. Its thickness varies from two to eight inches, and it rests upon a thin band of dark shales, to which succeeds a yard of grey sandy marls, containing hard concretionary nodules; beneath are bands of hard sandy marl, resting upon eight feet of pale-grey arenaceous marls,

[1] 'Memoirs of the Geological Survey of Great Britain,' vol. i, p. 253, 1846.

[2] 'Geological Transactions,' 2nd series, vol. i, pl. 37, 1824.

having at their base a nodular band of similar marls, passing into a thick bed of sandy marlstone, six feet six inches thick, and forming the base of the *Avicula contorta* series, which rests on nodular greenish marls, thick-bedded and red-striped, fourteen feet thick, and next a thick mass of marls fifty-two feet thick, having a conchoidal fracture; then follow the gypsiferous series, containing fibrous gypsum, in string-like lines, for twenty-five feet six inches, having at the base twenty feet of red sandy marls, the whole resting upon highly inclined strata of the lower portion of the Carboniferous Limestone, which here forms the bed of the Severn.

Penarth Cliff.

At Penarth Head, near Cardiff, a magnificent section is exposed, showing the Lower Lias and *Avicula contorta* beds resting on the variously coloured marls of the Keuper. The lowest half of the cliff is a roll of the same beds which occur at Garden Cliff, forty-four miles higher up the Severn. The upper part of the Head is composed of alternate beds of shale and limestone with *Arietites Turneri*, *Cardina ovalis*, *Gryphæa arcuata*, and *Pentacrinus tuberculatus*, fifteen feet thick, which overlie the Zone of *Arietites Bucklandi*, consisting of alternate beds of limestone and shale, which attain from fifty to sixty feet in thickness; and contain *Lima antiqua*, Sow., *Lima gigantea*, Sow., *Lima punctata*, Sow., *Lima pectinoides*, Sow., *Cardinia hybrida*, Stuch., *Unicardium cardioides*, Phil., with fragments of *Arietites Bucklandi*. Beneath the Lima-series are beds of laminated clay containing *Aegoceras planorbis*, Sow., with alternate strata of clay and limestone, and a profusion of *Ostrea liassica* on the surface of the slabs. They attain a thickness of ten feet, and are underlain by a bed of stiff clay containing *Ostrea liassica* and *Modiola minima*.

The *Avicula-contorta*-beds form an important feature in the cliff, consisting as they do of blackish shales interposed between the light-coloured marls of the Keuper below, and the light-coloured shales and limestone of the Planorbis-beds above; beneath are dark marly clays with impressions of teeth, scales, and shells that lie compressed in seams of clay, resting on a calcareous rocky band containing *Pecten Valoniensis*, Defr., closely pressed together, and badly preserved. Beneath this Upper Pecten-bed are several feet of dark shales, resting on a second stony band with *Pecten Valoniensis*, and this lower Pecten-band is underlain by shales and layers of ripple-marked micaceous sandstone, containing *Avicula contorta* and *Pullastra arenicola*, Strick. The Bone-bed occurs in the section, but is feebly represented, and often with difficulty discovered, as its contents are sparse, and often much comminuted. Two feet of Black Shales separate the sandstone from the Keuper.

In the county of Somerset there are several exposures of the Contorta-beds laid open either by railway-cuttings or by the action of the sea along the coast; to the former belong the Uphill Cutting near Weston-super-Mare. As I watched this exposure during its entire progress, and have studied it several times since, I give the details, for it is very typical of the others.[1]

[1] 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 382, 1860.

Uphill Railway-cutting, Bristol and Exeter Line.

	Lithological characters and thickness.	Beds.	Organic Remains.
Lower Lias. — Angulatum.	Alternate beds of light-coloured Lias limestones and shales, much fractured and disturbed to an angle of 40°. 10 feet.	The Angulatum Series.	Fragments of *Aegoceras angulatum* and *Aeg. liassicum.*
Lower Lias. — Planorbis.	Dark-greyish laminated shales interstratified with thin bands of limestone, and beds of clay, thickness 14 feet.	Planorbis Series.	*Aegoceras planorbis,* much compressed between the shaly laminæ, the white outer layer of the shells is well preserved.
Lower Lias. — Ostrea.	Bands of limestone, 6 inches. Do. of shale, 3 feet 6 inches. Do. of limestone, 4 inches. Do. shale, 3 feet. Succeeded by 12–14 beds of limestone and shales, 12 feet.	Ostrea Series.	*Modiola minima, Ostrea liassica, Pleuromya Crowcombeia, Astarte obsoleta.* These fossils were found sparingly on the surface of the slabs.
Avicula contorta series. — Black Shales, Bone-bed, and Pecten-beds.	A thin band of dark grit, 1½ inches, resting upon dark-grey shaly marl, 4 feet 6 inches.	Dark Grit.	Teeth and Scales of Fishes.
		Black Shales.	Fossils rare.
	Dingy-coloured pyritic limestone, many shells, 2 inches.	Upper Pecten-bed.	*Pecten Valoniensis.* *Cardium Rhæticum.*
	Grey marl, 2 inches, resting on a band of limestone with shells and gypsum, 2 inches, and dark marl, 4 feet.	Grey Marl with Gypsum.	*Avicula contorta.* *Cardium Rhæticum.* *Axinus cloacinus.*
	Dark shelly pyritic limestone, 6 inches.	Lower Pecten-bed.	*Pecten Valoniensis.* *Avicula contorta.* *Isodonta præcursor.*
	Dark marls, 3 feet. Laminated Shale, 3 inches. Dark marl, 1 foot 9 inches. Stony band of impure limestone, 3 inches.	Lower Dark Marls and Shales.	Many small shells in compressed seams lie within the laminæ of the shales, as *Pullastra, Axinus,* and *Avicula contorta.*
	Dark pyritic conglomerate; coprolites' teeth, and scales of Fishes, 2 inches thick.	Bone-bed.	Teeth and scales of Fishes. *Saurichthys, Hybodus, Gyrolepis.*
	Dark shaly marl, 3 feet 6 inches. Dark stony band, 8 inches. Dark indurated marl, 2 feet. Band of limestone, 6 inches. Dark indurated marl, resting on a pebbly conglomerate, 3 feet 6 inches.	Lower Black Shales.	These black shales are not fossiliferous.

The Lower Black Shales rest upon beds of pale green and grey marls, interstratified with bands of limestone which are here interposed between the Contorta-series and the Red Marls of the Keuper.

In this cutting, when first made, the uppermost portion of the grey marls was overlain by a thin bed of conglomerate formed of small round quartz pebbles, and on this rested the basement layer of the Black Shales. The Bone-bed was uniformly thin and found with difficulty *in sitú*, although fragments of it were discovered on the spoil-banks. I have collected from these many good specimens of teeth and scales of the Fishes in the list.

The Lower Pecten-bed is a slate-coloured, pyritic, semi-indurated shale, containing many compressed bivalved shells in tolerable preservation, and the dark shales between the two Pecten-beds have a few fossils closely compressed between the laminæ.

The Upper Pecten-bed was very rich in Conchifera, which were enclosed in a hard, argillaceous limestone with iron; so the fossils were too pyritic to be preserved, otherwise a larger list might have been added.

At Puriton is another railway-cutting in which the Contorta-series is well exposed; and the Bone-bed was found to be richly fossiliferous. In this cutting the Ostrea- and Planorbis-beds of the Lower Lias were likewise well laid open.

The railway-cutting near Shepton Mallet affords another instructive section of the Contorta-series overlain by the Ostrea-, and Planorbis-, and Angulatum-beds of the Lower Lias; and similar sections are exposed likewise near Wells, and Whitchurch, and at Saltford and Weston, near Bath. The latter show the relation of the Contorta-series to the Lias extremely well, as will be seen in the sequel.

A very fine coast-section of the Contorta-series, ranging from the tea-green and grey Marls through the Black Shales and Limestones of the Lower Lias, is admirably exposed at St. Audrey's Slip, two miles east of Watchet. At the base are seen the red marls of the Keuper having in succession the tea-green marls, and above alternating beds of pale-grey, hard, and soft marls, resting on beds with strontian and gypsum. The pale grey marls are overlain by black shales, which collectively are here about forty feet thick, and almost unfossiliferous. The black shales are overlain by a band of nodular limestone containing *Cardium Rhæticum*, *Axinus depressus*; above this band comes in dark grey, sandy shales with the Bone-bed, consisting of a grey calcareo-siliceous rock, enclosing the teeth of *Saurichthys apicalis*, *Acrodus minimus*, and *Hybodus*. The Bone-bed is overlain by dark shales, and inconstant bands of limestone, containing *Avicula contorta*, *Pecten Valoniensis*, *Anatina Suessii*, *Myophoria postera*, and other Conchifera. The dark-grey shales, some of which are indurated and ripple-marked, are sixteen feet thick, and are overlain by the Cotham Marble-bed, on which rests eight feet of the White Lias series, containing the Sun-bed; on this reposes a series of laminated shales five feet thick, some of the beds containing immense numbers of Pullastra, similar to the condition of the same beds at Pinhay Bay, on the Dorset coast. These shales separate the White Lias from the Ostrea-series, fifteen feet thick, which succeeds in the section.

The Contorta-beds have likewise been found in Warwickshire, Staffordshire, and Leicestershire, also at Colin Glen, near Belfast, and in other localities in Ireland.[1] The sections discovered in these counties and Ireland closely resemble those already described. The following list contains the fauna special to the *Avicula-contorta*-zone:

Echinodermata.

Ophiolepis Damesii, *Wright*. Garden Cliff; Leicestershire; Warwickshire; Hildesheim, N. Germany.

Lamellibranchiata.

Avicula contorta, *Portlock*.
— solitaria, *Moore*.
Lima precursor, *Quenst*.
Modiola minima, *Goldf*.
Placunopsis alpina, *Moore*.
Plicatula intusstriata, *Emmerich*.
Gervillia præcursor, *Quenst*.
Pecten Valoniensis, *Defrance*.
— Rhæticus, *Merian*.
Pleuromya Crowcombeia, *Moore*.
Myophoria inflata, *Emmerich*.
Pleurophorus elongatus, *Moore*.
— angulatus, *Moore*.
Anatina præcursor, *Quenst*.
— Suessii, *Oppel*.
— elongata.
Schizodus depressus, *Moore*.
— elongatus, *Gümbel*.
— concentricus, *Moore*.
Cardium Rhæticum, *Merian*.
Cypricardia Suevica, *Oppel*.
Pullastra arenicola, *Strickland*.

Gasteropoda.

Cylindrites elongatus, *Moore*.
— fragilis, *Dunker*.
Chemnitzia alpina, *Dittmar*.
— granum, *Dittmar*,

Crustacea.

Cypris? liassica, *Brodie*.
Estheria minuta, var. Brodieana, *Jones*.
Pollicipes Rhæticus, *Moore*.
Tropifer lævis, *Gould*.

Pisces.

Acrodus minimus, *Agass*.
Saurichthys apicalis, *Agass*.
— acuminatus, *Agass*.
Sargodon tomicus, *Plieninger*.
Nemacanthus monilifer, *Agass*.
— filifer, *Agass*.
Gyrolepis tenuistriatus, *Agass*.
— Alberti, *Agass*.
Hybodus pyramidalis, *Agass*.
Hybodus minor, *Agass*.
— plicatilis, *Agass*.
— lævisculus, *Agass*.
Ceratodus altus, *Agass*.
— trapezoides, *Plien*.
— emarginatus, *Agass*.
— gibbus, *Agass*.
— latissimus, *Agass*.
— obtusus, *Agass*.

Reptilia.

Plesiosaurus.
Ichthyosaurus.

[1] Portlock, 'Geol. Report, Londonderry,' pp. 126-127, 1843; Tate, 'Quart. Journ. Geol Soc.,' vol. xx, pp. 105-107, 1864.

Mammalia.

Microlestes antiquus, *Plieninger*, in the Bone-bed of Würtemberg, and in the Rhætic Breccia of Somerset.

M. (Hypsiprymnopsis) Rhæticus, *Dawkins*, Rhætic Beds, Watchet.

Foreign Correlations.—The Zone of *Avicula contorta* has a wide geographical range on the Continent of Europe, where the beds are found with lithological and palæontological characters very similar to those already described in the English counties, thus—

In South-west Germany they are developed in Württemberg near Tübingen, near Balingen, in the neighbourhood of Stuttgart, and near Nürtingen and Esslingen. In the Langenbrücker Jura at Malsch and Osvingen, in Baden; in Bavaria, at Bamberg and Baireuth; in Coburg, at Gotha in North-west Germany, near Brunswick, near Hildesheim, near Hanover, and in the vicinity of Göttingen.

In Switzerland, near Basel, and in the Canton of Argau, and in the Vaudois Alps, and in the Eastern, Western, and Italian Alps.

In France, in the departments of the Haute Saône, in the Franche Comté, in the Meurthe, Moselle, and Côte d'Or, Aveyron, Herault, Var, Mont d'Or, near Lyons, and Saint-Sorlin Saône-et-Loire, and in Luxembourg and Belgium.

In Lombardy they have a wide extent and great thickness, and are found in the north-west of Hungary at many points in the Carpathians. They are found likewise in Sweden as sandstone, shales, and coal, with plant remains, and attain a considerable thickness.

A careful review of the fauna shows—

1. That the zone of *Avicula contorta* contains a special assemblage of species, few of which are limited to any one bed.

2. That the vertebrata represented by Fishes are all more closely connected with the well-known forms of the Trias, and are claimed by Ichthyologists as such.

3. That the Molluscan fauna contains two or three species that ascend into the Lias, but are never found in the Trias beds, whilst the greatest number are special to the zone, and have many organic affinities in relation with Triassic species. For these reasons it is contended that the Contorta-beds are truly Triassic.

THE LOWER LIAS.

1. The Zone of Aegoceras planorbis.

Synonyms.—"White Lias," William Smith, 'Memoir to the Map,' p. 47, 1815. "White Lias (pars)," De la Beche, 'Geol. Trans.,' 2nd series, vol. ii, p. 26, 1826. "Saurian Beds," Murchison's 'Geology of Cheltenham,' 2nd ed. by Buckman and Strickland, p. 49, 1845. "Psilonotenbank," Quenstedt, 'Der Jura,' Table, p. 293, 1857. "Die Schichten des Ammonites planorbis," Oppel, Juraformation,' p. 24, 1856, "Zone of

Ammonites planorbis," Wright, 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 389, 1864. "Zone de l'Ammonites planorbis," Dumortier, 'Études Paléont.,' t. i, p. 15, 1864. "Die Psilonotonschichten," Brauns, 'Die untere Jura,' p. 55, 1871. "Zone of Ammonites planorbis," Tate and Blake, Yorkshire Lias, p. 38, 1876.

This division of the Lower Lias is well developed in the South of England.[1] In general it consists of a series of thin, greyish, or bluish, argillaceous limestones, with alternating beds of laminated shale; or it forms sometimes the upper part of the thick-bedded, argillaceous, cream-coloured limestone, called "White Lias" by William Smith. In the upper half of this group *Aegoceras planorbis* (Sow.), in some localities, is found in considerable numbers, compressed in the shales, with the outer layer of its white shell more or less preserved; in the lower portion of the series *Ostrea liassica*, Strick.,[2] appears in great numbers; and beneath these strata are three or four beds of hard limestones (or "firestones"), in which the finest skeletons of *Enaliosauria* have been discovered. As this distinction, by means of *Æ. planorbis*, *Ostrea liassica*, and Saurians, is a practical and useful one in the investigation of this zone of life, I shall adhere to it on the present occasion,—premising, however, that *Ammonites* are very rare in the lower beds, and numerous in the upper; and that *Ostreæ* are abundant below, and rare above, whilst Saurian remains are found throughout the entire series.

The best sections of the *planorbis*-zone are those afforded by the extensive quarries at Street and the coast-sections at Watchet, and St. Audrey's Slip, in Somerset;[3] at Binton and Wilmcote, in Warwickshire; and at Pinhay Bay and Up-Lyme, in Dorset. I purpose giving a detailed description of the most typical sections in each county.

Somersetshire.—At Street the strata are nearly horizontal and undisturbed, and therefore admit of accurate measurement. The following section of Mr. Cree's quarry I have compared with like sections afforded by the quarries of Messrs. Seymour, Underwood, and Talbot in the same parish; and find that the variation is so inconsiderable that any one may be said to represent the others, both as regards the sequence of the beds and the fossils they contain.

[1] The substance of the following observations on the Lower Lias is contained in my memoir on the 'Zone of Avicula contorta, and the Lower Lias of the South of England," 'Quart. Jour. of the Geological Society,' vol. xvi, p. 374, 1864.

[2] *Ostrea liassica*, Strickland, is a very characteristic shell of the lowest Lias beds. It resembles *Ostrea irregularis*, Münster (Goldfuss, 'Petr. Germ.,' pl. vii—ix, fig. 5), and *Ostrea rugata*, Quenstedt ('Jura,' pl. iii, fig. 17). Dunker, in the 'Palæontographica' (pl. vi, fig. 27), has figured a small Oyster from the Lias of Halberstadt (*Ostrea sublamellosa*, Dunker), which appears to be identical with our species. These small, thin, rugose Oysters are found in great abundance in the lowest beds of the Lower Lias in England and Germany. They are probably only varieties of one species, which had a wide geographical distribution in the seas which deposited the basement-beds of the Lias.

[3] R. Etheridge, F.G.S., "Physical Structure of the Watchet Area," 'Proc. Cotteswold Nat. Field Club,' 1871, p. 40, and section No. 6.

Section of the Zone of Aegoceras planorbis, *at Street, Somerset.*

No.	Lithology and Local Names of Beds.	Thickness. ft.	in.	Organic Remains.
				Planorbis Series.
1	Light-coloured marly clay. "Top Bed"	3	0	Saurian bones and *Aegoceras planorbis*.
2	Light-coloured Lias limestone	0	9	*Aegoceras planorbis* in moulds.
3	Yellowish laminated shale, splitting up into thin layers	3	0	*Ichthyosaurus intermedius, Aegoceras planorbis, Lima punctata*, and *Isastræa Murchisoni*.
4	Light-coloured shaly limestone	0	4	*Aegoceras planorbis*, compressed.
5	Hard grey limestone. "Building-stone"	0	7	*Aegoceras planorbis*, on the top of the bed, *Lima punctata* and *Lima gigantea*.
6	Dark-grey shale	0	3	*Aegoceras planorbis* and muricated spines of *Cidaris Edwardsi*.
7	Dark-grey limestone. "Corn-sized building-stone"	0	6	Spines of *Cidaris* and bones of *Ichthyosaurus tenuirostris*.
	Ostrea Series.			Ostrea Series.
8	Dark laminated shale	0	4	*Ostrea liassica*.
9	Dark-grey limestone. "Five-inch building-stone"	0	5	*Ostrea liassica*.
10	Dark shale	0	3	*Ostrea liassica*.
11	Dark-grey limestone. "Six-inch building stone"	0	6	*Cardinia crassiuscula, Lima punctata*, and *Ostrea liassica*.
12	Dark shale	0	6	—
13	Greyish hard limestone. "The Whetstones." Best paving-bed. Consisting of two 4-inch beds	0	8	Fossils rare: *Ostrea liassica* and *Modiola minima*.
14	Hard dark marl. "Saurian bed"	0	9	Many Saurians have been obtained from this bed. *Ichthyosaurus intermedius* and *Plesiosaurus Hawkinsii* (British Museum). Many jaws of Saurians and Fishes.
15	Greyish fine-grained limestone. "The Cream-bed." Fine-grained paving-stone	0	3	*Ostrea liassica* and *Modiola minima*.
16	Brownish limestone. "Red Liver." Paving-stone	0	4	Few fossils.
17	Dark-coloured limestone. "The Black stone," used for large paving-slabs; some of them 10 ft. by 5 ft.	0	4	*Modiola minima, Ostrea liassica, Pleuromya*, and *Rhynchonella variabilis*.
18	Dark-blue shale	0	2	*Ostrea liassica* and *Modiola minima*.
19	Hard greyish limestone. "Six-inch building-stone"	0	6	*Ceromya, sp., Modiola minima*, and *Ostrea liassica*.
20	Soft bluish shale	0	2	—
21	Greyish-blue limestone. "Four-inch building-stone"	0	4	Fossils as in No. 19.
22	Dark-gray laminated shale	0	4	*Ichthyosaurus intermedius* and *I. tenuirostris*.
23	Hard blue limestone. "The Blue Clog," or "One-foot building-stone," used for steps	1	0	*Ceromya, sp., Ostrea, Modiola*, and *Rhynchonella*.
24	Grey laminated shale	1	3	Saurians abundant: *Ichthyosaurus intermedius* and *I. tenuirostris, Pholidophorus leptocephalus*, Agass.
25	Greyish limestone. "Grey Clog." A valuable building-stone, used for steps, troughs, &c.	1	0	*Modiola minima*.
26	Dark shale	0	2	—

No.	Lithology and Local Names of Beds.	Thickness.	Organic Remains.
		ft. in.	
27	Thin-bedded limestone. "Three-inch blue bed"	0 3	Fish remains, *Modiola minima* and *Otopteris acuminata*, L. & H.
28	Thick blue limestone	0 5	—
29	Hard fine-grained limestone. "Firestone"	0 4	—
30	Hard, grey, fine-grained limestone	0 4	*Plesiosaurus Etheridgii.* (In Jermyn Street Museum; and another in Street are from this bed.)
31	Hard grey limestone. "Fire-stone, bottom bed"	1 0	*Plesiosaurus Hawkinsii.* [The large *Ples. megacephalus*, Stutch., now in the Bristol Institution, was obtained from this bed near Street.]

The Saurian beds near Langport have likewise yielded Reptilian remains. I obtained two fine specimens of *Ichthyosaurus intermedius* and an imperfect specimen of *I. tenuirostris* from this locality; the former is now in the Collection of the Earl of Ducie. In connection with the Saurian beds of Somerset, it is important to note that the oldest *Enaliosauria* of the Lias are *Plesiosaurus Hawkinsii*, Owen, and *Pl. Etheridgii*, Huxley, which were both exhumed from the 4-inch firestone, forming the bottom bed of the Ostrea-series; the remarkable *Plesiosaurus megacephalus*, Stutch., now in the Bristol Museum, was likewise found in the firestones of a quarry near Street Foss; and it will be shown in my section of the correlative beds of this zone at Wilmcote, in Warwickshire, that the fine skeleton of *Plesiosaurus megacephalus* contained in the Warwick Museum was also exhumed from the "firestones" of that locality—beds which are the true equivalents of the "firestones" of Street.

The small number of *Lamellibranchiata* hitherto found in these beds is very remarkable. *Ostrea liassica*, Strickl., *O. irregularis*, Quenst., *Modiola minima*, Goldf., *M. psilonoti*, Quenst., *Gervillia Hagenovii*, Dunk., *Anomya striatula*, Opp., *Pleuromya Crowcombeia*, Mor., *Macrodon Hettangiensis*, Terq., and *Protocardia Phillippiana*, Dunk., are the only species I have as yet collected from the firestone-beds.

This section likewise settles a question which has been often discussed, namely, what is the age of the Saurian beds of Somersetshire? It has been supposed that they appertain to the same horizon as the lower Saurian beds at Lyme Regis, Dorsetshire; this, however, is a mistake, inasmuch as the Saurian beds at Street belong to the zone of *Aegoceras planorbis*, whilst the Saurian remains at Lyme Regis, on the contrary, are for the most part found in and above the zone of *Arietites Bucklandi*.

Worcestershire and Gloucestershire.—The *Planorbis*-, *Ostrea*-, and *Saurian*-beds so well developed at Street, are likewise found in different parts of Worcestershire and Gloucestershire, where they present the same stratigraphical relations, and yield the same organic remains.

The neighbourhood of Tewkesbury affords several good exposures of these infra-ammonite beds. I have obtained *Ichthyosaurus tenuirostris*, Conyb., and *Ichthyosaurus*

intermedius, Conyb., from a bed of light-coloured Lias at Haselgrove, near the "Folly;" and the late Mr. Dudfield collected several very fine skeletons of *Ichthyosaurus tenuirostris*, Conyb., *I. intermedius*, Conyb., and *I. communis* (?), Conyb., with bones of *Plesiosaurus Hawkinsii*, at Brockeridge Common, and from similar beds in other localities near Tewkesbury; and I possess several vertebræ of *Plesiosaurus rugosus*, Owen, which were obtained from a bed of Lower Lias at Woolridge, near Hartpury.

The junction of the Lower Lias with the red marls of the Keuper in the Vale of Gloucester is, in general, indicated by a low escarpment, facing the west. At Brockeridge and Defford Commons this natural boundary is exceedingly well marked, and between these two localities are several quarries which expose to a greater or less extent the beds now under consideration. The presence of *Aegoceras planorbis* in the upper strata of these sections has enabled me to correlate the beds beneath with the corresponding strata at Street, in Somerset, and at Binton, Grafton, and Wilmcote, in Warwickshire.

Section of the Planorbis-, Ostrea-, *and* Saurian-beds *at Brockeridge and Defford Commons.*

Zones.	Strata and Organic Remains.	Brockeridge.	Strensham.
		ft. in.	ft. in.
Planorbis-beds.	1. Light-coloured clay	3 0	3 0
	2. White laminated limestone. "First rub," Brockeridge; "Chance rub," Strensham	0 4	0 4
	3. Brown laminated clay, with compressed white shells of *Aegoceras planorbis*	3 0	2 0
	4. Blue argillaceous limestone } "Double rub," Brockeridge;	0 3	0 2
	5. Brown shaly clay } "Double nurf," Strensham.	0 2	0 2
	6. Blue limestone }	0 3	0 2
Ostrea- and Lower-Saurian Beds.	7. Dark clay, with Saurian remains. "Yard clay"	3 0	3 0
	8. Hard blue limestone. *Ostrea liassica* on the surface of the rock. This bed is called "Red nurf" at Brockeridge, "King's nurf" at Strensham	1 0	0 3
	9. Dark clay. The second bed of "Yard clay" at Strensham	1 6	3 0
	10. Blue limestone. The "Queen's nurf," Strensham	0 3	0 3
	11. Blue clay	0 0	0 3
	12. Hard blue limestone, with *Modiola minima*	0 0	0 6
	13. Paving-stone, separated by an inch-band of clay	0 0	0 4
	14. Dark shale. Vertebræ of *Icthyosaurus*, tests and spines of *Cidaris Edwardsi*, *Hemipedina Tomesii*, and Fishes' scales	0 0	0 6
	15. Hard blue limestone, in square blocks. "Brick-bed"	0 0	0 5
	16. Dark shale	0 0	0 3
	17. Insect-limestone of the Rev. P. B. Brodie, F.G.S.; a hard argillaceous limestone, containing the Elytra and other remains of Insects	0 0	0 6
	18. Blue shale	0 0	1 3
	19. Light-blue limestone, with *Cardinia ovalis*, *Macrodon Hettangiensis*, and *Astarte obsoleta*	0 0	0 4

I have placed the sections together for the purpose of comparison: they were first made by my friend, the Rev. P. B. Brodie, F.G.S., and have been often examined since with similar results. These sections show the uniformity which prevails in the Lower Saurian beds of Gloucestershire and Worcestershire, and how much they resemble their correlative strata at Street.

The late Mr. Dudfield, of Tewkesbury, obtained from the Ostrea-beds at Brockeridge Common, enumerated in the preceding sections, and from other strata occupying the same horizon in the vicinity of that town, a very fine series of Saurian remains, which were all sold and dispersed in June, 1843. From my notes of that collection I find there was a specimen of *Ichthyosaurus intermedius*, about 8 feet in length; the two fore-paddles and a portion of the scapular arch were tolerably complete; and there were upwards of 100 vertebræ, and many ribs nearly all in place. *I. tenuirostris;* 4 feet in length; the skull, jaws, and teeth were well preserved, and the vertebral column was tolerably complete; likewise one fore-paddle. *I. communis;* very fine paddles. *I. platyodon;* large skull, with orbital plates in position. *Plesiosaurus Hawkinsii;* the vertebral column, ribs, and humeri; and fifty vertebræ in position.

The *Ostrea*- and *Saurian*-beds at Binton, Brockeridge, and Street are overlain by clays and laminated shales, containing *Aegoceras planorbis*. As these beds form a most important horizon in the Lias formation, and have a wide geographical distribution in England, France, and Germany, they require to be defined with accuracy, especially as some authors are of opinion that the true Lias commences with this zone of life.

The relation of the *Planorbis*-shales to the Saurian beds below is extremely well exposed in the Railway-cutting at Uphill and in the quarries at Street, Somerset; at Binton and Wilmcote, in Warwickshire; at Brockeridge Common, in Gloucestershire; at Strensham, Worcestershire; and to the *Bucklandi*- or *Lima*-beds above in the sections at Saltford, near Bristol; Penarth Head, near Cardiff; Pinhay Bay, near Lyme Regis; and St. Audreys Slip, near Watchet, Somerset.

The following section of the beds at Binton was made by Mr. R. Tomes, F.Z.S., from a working now abandoned. A similar exposition, however, was seen in the quarry worked near the former, which I examined and measured with Messrs. Tomes and Kershaw.

Section of the Zones of Aegoceras planorbis *and* Avicula contorta, *at Binton, Warwickshire.*

No.	Lithology and Local Names of Beds.	Thickness.	Organic Remains.
		ft. in.	
1	Light-coloured limestone. "Top rock" or "Whites"	0 6	—
2	Light-coloured clay	2 6	—
3	Argillaceous limestone. "Top Liveries"	0 3	*Ichthyosaurus;* on the upper surface, Insects.

No.	Lithology and Local Names of Beds.	Thickness.	Organic Remains.
		ft. in.	
4	Light-coloured clay	7 0	—
5	Argillaceous limestone. "Top Liveries" (lower)	0 3½	*Aegoceras Johnstoni*, Sow. Insects' wings.
6	Clay	1 1	—
7	Greyish limestone. "Extra rock," "Thick paving-bed"	0 6	No fossils.
8	Clay	0 3½	—
9	Greyish limestone. "Quarters." Thin and irregular when covered by the preceding..... 2 in. to	0 3	—
10	Clay	0 8½	—
11	Greyish limestone. "Ribs." A constant bed	0 3½	Insects.
12	Clay	0 5½	—
13	Limestone. "Paving-stone"	0 3	A few Insects, and *Pholidophorus Stricklandi*, Ag.
14	Clay	0 10½	—
15	*Insect* Limestone. "Bottom rock"	0 3¼	More Insects here than in all the other beds collectively.
16	Clay	0 8	—
17	Limestone. "Hoggs" ..... 3 in. to	0 6	*Tetragonolepis angulifer*, Ag. (Warwick Mus.)
18	Strong hard clay	0 3½	No fossils in this bed.
19	Argillaceous limestone; imperfect stone. "Ruskin"	0 3	—
20	Laminated clay	1 6	—
21	Fragmentary shelly limestone. "Grizzle bed"	0 1½	Saurian bones, Fishes' teeth and scales, *Aegoceras planorbis*, *Lima punctata*, *Protocardia Phillippiana*, and *Ostrea liassica*; spines of *Cidaris* and other *Echinidæ* abundant.
22	Stony shale.	—	—
23	Hard limestone. "Blue stone" or "Blocks"	0 6	*Pleuromya Crowcombeia*, and elytra of *Coleoptera*.
24	Hard clay	1 3	
25	Limestone. "Grave-stone rock"	0 3½	*Ichthyosaurus* and *Otopteris acuminata*, Lin. & Hut.
26	Clay. Thin hard plates of stone lie in this clay	0 11	—
27	Limestone, underlain by clay. (The clay frequently wanting)	0 0½	—
28	Limestone; inconstant. "Gummerals"	0 6	*Ostrea liassica*.
29	Clay.		—
30	Hard grey limestone. "Fire-stone beds"	0 6	Saurian remains and *Protocardia Phillippiana*.
31	Clay	0 2	*Modiola minima*, *Pl. Crowcombeia*, and *O. liassica*.
32	Limestone	0 3	In these limestones and clays only *one* small
33	Clay	0 2	*Aegoceras planorbis* has been found.
34	Limestone	0 3	
35	Clay	0 3	
36	Hard dark limestone. "The Guinea-bed." (This is the bottom bed of the quarry) ..... 1 in. to	0 10	Saurian bones, *Avicula longicostata*, Stutch., *Monotis fallax*, *Lima punctata*, *Pleuromya Crowcombeia*, *Ostrea liassica*, *Hemipedina Tomesii*, Wr., in numbers; *Septastræa*.
	Avicula Contorta Beds.		
37	Thick clay-beds; yellowish blue; breaking in angular fragments	8 0	[Belonging to the zone of *Avicula contorta*.]
38	Dark ferruginous clay, with conchoidal fracture, the Estheria-bed.	8 0	*Estheria minuta*, var. *Brodieana*.

No.	Lithology.	Thickness.	Palæontology.
		ft. in.	
39	Clay. "Clear blue blocks"	?	—
40	Laminated clays	3 0	—
41	Light-coloured micaceous sandstone ...	0 1	*Pullastra arenicola*, Strickl.
42	Brown clay	0 2	—
43	Sandstone; micaceous.....	0 2	*Pullastra arenicola*, Strickl.
44	Dark shaly clay	0 6	—
45	Soft sandstone	0 1	—
46	Black clay.....	0 3	—
47	Ferruginous sandy vein	?	—
48	Grey Keuper marls.		—

The beds from No. 37 to N. 48 were found *in sitú* in an escarpment at a short distance from the quarry at Binton. The "Guinea-bed" is the lowest stratum seen *in sitú* in the pit, and No. 37 occupies its natural position relatively to that bed, although not exposed in the Binton section.

Lithology.—The *Planorbis*-beds at Brockeridge (p. 18) consist of dark, laminated shales, with interstratified beds of marl and limestone. The shales split into very thin laminæ, between which innumerable shells of *Aegoceras planorbis* lie closely compressed; the white, calcareous, pulverulent material of the shells forming a strong contrast to the dark shales enclosing them. In Somersetshire, at Uphill, the rock consists of shales which greatly resemble those at Brockeridge; at Watchet, of dark clays which are more indurated and have the shell-structure better preserved: *Aegoceras planorbis* and *Aeg. Johnstoni* are here found with the iridescent nacreous layer of their shells beautifully lustrous. At Street the rock is a light-yellowish clay, with bands of greyish limestone and marl beneath, and in Worcestershire at Strensham, and in Warwickshire at Binton, similar lithological conditions prevail.

The White Lias series of the section at Saltford (see p. 37) represents in part the *Planorbis*-beds: the relations of that zone to the Saurian beds below, and to the *Bucklandi*-beds above, are here also well shown. In Dorsetshire the *Planorbis*-beds are represented by the upper portion of the White Lias so well exposed in the large quarries at Up-Lyme, where it is raised for caustic lime, and in the coast-sections at Charlton and Pinhay Bays; and consists of a fine-grained, cream-coloured limestone. The two principal quarries afford the necessary details. Mr. Webb's quarry shows—

In the uppermost portion, thin bands of grey limestone interstratified with shales; in these are found *Aegoceras planorbis* and *A. Johnstoni;* in two thick beds of dark, shaly clay are numerous spines and plates of sea-urchins, as *Cidaris Edwardsii*, Wrt., *Pseudodiadema lobatum*, Wrt., *Hemipedina Bechei*, Brod., *Hemipedina Bowerbankii*, Wrt. These same shales are found at low-water mark at Pinhay Bay, and have yielded nearly all the Echinidæ said to be found in the Lower Lias at Lyme Regis.

Beneath the lower bed of the Cidaris-shales are several thin beds of light-coloured limestone, locally called Whetstones, and separated by intermediate shales; then in descending order come the beds known as Grey Burr, Rotten Burr, Fire-stones, Cliff-ledge, Half-foot, One-foot, Red Size, and Anvil-ledge, all separated by thin bands of shale; on the surface of the limestones and in the shales are many fossils, among which *Ostrea liassica* forms the dominant shell. The shale above Anvil-ledge contains great numbers of *Pullastra arenicola*, Strickland, apparently indicating a change of condition in the series of beds which lie below this fossil band. The beds from the Whetstones to the Pullastra-shales represent the Ostrea-series, and from the circumstance of the exposed edges of the rock having weathered to a cream-colour, they form the upper portion of the White Lias. The lower portion of this formation differs both lithologically and palæontologically from the upper portion; it is a compact, earthy limestone, with conchoidal fracture, cream-coloured, and close-grained; and many of the beds are so fine that they might be used as lithographic stone. Beneath Anvil-ledge are three feet of light-coloured, rubbly beds, containing *Modiola minima*, *Ostrea liassica*, *Pleuromya Crowcombeia*, resting upon eighteen inches of White Lias; then follow a series of irregular beds, with thin partings, twelve feet in thickness, which overlie a bed, twenty-one inches thick, of fine, white limestone, resting on a like thickness of shale; beneath this is a bed of smooth, regular, fine, white limestone, six feet thick; then a bed of shale; and at the base of the series is a band of Cotham marble or Landscape-stone. The lower portion of the White Lias from the Pullastra-shales downwards represent, I believe, the upper beds of the *Avicula-contorta*-zone; there are many fossils in the limestones, which have not yet been determined. I have found casts of *Cardium Rhæticum*, *Monotis decussata*, *Pullastra arenicola*, and shells of *Pecten Valoniensis*. Unfortunately the fossils are mostly in the form of moulds, and for this reason we must wait until better specimens are obtained. The lower portion of the White Lias series is only seen in Mr. Fowler's quarry at Up-Lyme.

The coast-section at Pinhay Bay is a complete repetition of the Up-Lyme quarries; the Cidaris-shales are well exposed at low water during spring-tides, and from them are obtained all the *Echinidæ* found in the section. I know of no *Asteriadæ* in these beds.

In Gloucestershire this zone is well exposed at Brockeridge Common, and at Wainlode, in a quarry on the right-hand side of the Gloucester Road, between Hartpury and Ashelworth, and at Elmore, in quarries near the Old Kennel.

In Glamorganshire it is seen in the fine coast-section at Penarth Head. In Somersetshire, in the cutting of the Great Western Railway at Saltford; in the Uphill Cutting on the Bristol and Exeter Railway; in the coast-section at St. Audreys Slip, near Watchet; and in all the quarries at Street.

In Worcestershire it is found at Strensham; and in Warwickshire at Binton, Grafton and Wilmcote.

It is likewise found at Robin Hood's Bay, on the coast of Yorkshire; the beds lie here below low-water mark, and large blocks, frequently washed up by the tide, are literally crowded with *Aegoceras planorbis*, known at Scarborough and Whitby as *Aeg. erugatum*, Bean.

The Coral-bed at Lussay, Isle of Skye,[1] probably represents this zone, as I found the same species of *Anthozoa* as the Hebridean Coral *Isastræa Murchisoni*, Wrt., in the light-coloured clays with *Aeg. planorbis* at Street.

This lower Ammonite-zone has, therefore, a wide geographical range throughout the Lower Lias of the northern, midland, and southern counties of England, and retains the same relative position in the Lower Lias of France, Germany, and Switzerland.

The detailed sections which I have given of the Planorbis-zone form some of the best known types of the basement-beds of the Lias in England, and enable us to understand their relations to the CONTORTA-series below, and the ANGULATUM-strata which succeed them.

Fossils of the Planorbis-beds.—The fauna of this zone is very limited; at present I know only the following species from the English beds:

Ichthyosaurus intermedius, *Conyb.*
— tenuirostris, *Conyb.*
— communis, *Conyb.*
Plesiosaurus Hawkinsii, *Conyb.*
— Etheridgii, *Huxl.*
— rugosus, *Owen.*
— dolichodeirus, *Conyb.*
— megacephalus, *Stutch.*
Dapedius, sp. ined.
Pholidophorus leptocephalus, *Ag.*
— Stricklandi, *Ag.*
Aegoceras planorbis, *Sow.*
— Johnstoni, *Sow.*
Lima punctata, *Sow.*
Lima gigantea, *Sow.*
— pectinoides, *Sow.*
Cardinia crassiuscula, *Sow.*
Unicardium cardioides, *Phil.*
Ostrea liassica, *Strick.*
Protocardia Phillipsiana, *Dukr.*
Pleuromya Crowcombeia, *Moore.*
Rhynchonella variabilis, *Schloth.*
Cidaris Edwardsii, *Wrt.*
Pseudodiadema lobatum, *Wrt.*
Hemipedina Bechei, *Brod.*
— Bowerbankii, *Wrt.*
Hemipedina Tomesii, *Wrt.*
Isastræa Murchisoni, *Wrt.*

Foreign Correlations.—In the North of Germany the PLANORBIS-beds are well developed, and in some parts contain a Flora in which are found many species that appeared for the first time in the CONTORTA-zone; the most important genera are *Equisetum*, *Dictyophyllum*, *Clathropteris*, *Glossopteris*, *Tæniopteris*, *Pterophyllum*, *Zamites*, *Nilssonia*, and many others.

The Molluscan fauna contains many species which are common to this and the Angulatum beds; the following species were nearly all collected at Halberstadt, and

[1] 'Quart. Journ. Geol. Soc.,' vol. xiv, pp. 4 and 34.

many of them were figured and described by Dr. Dunker in the 'Palæontographica' some years ago.

Cephalopoda.

Aegoceras planorbis, *Sow.*
— Johnstoni, *Sow.*
— Hagenovii, *Dukr.*
Aegoceras angulatum, *Schloth.*
— laqueum *Quenst.*
Nautilus intermedius, *Sow.*

Gasteropoda.

Cylindrites fragilis, *Dukr.*
Patella Schmidtii, *Dukr.*
— subquadrata, *Dukr.*
— tenuis, *Dukr.*
Dentalium Etalense, *Terq.*
Pleurotomaria rotellæformis, *Dukr.*
Discohelix pygmæus, *Dukr.*
Euomphalus liasinus, *Dukr.*
Neritina liasina, *Dukr.*
Turritella Zenkéni, *Dukr.*
Hydrobia Krausseana, *Dukr.*
— solidula, *Dukr.*
Hydrobia subulata, *Dukr.*
Rissoa liasina, *Dukr.*
Littorina inornata, *Terqm.*
Cerithium gratum, *Terqm.*
— Etalense, *Piette.*
Purpurina angulata, *Dukr.*

Lamellibranchiata.

Ostrea sublamellosa, *Dukr.*
— ungula, *Münst.*
Hinnites inæquistriatus, *Goldf.*
Pecten textorius, *Schloth.*
Lima pectinoides, *Sow.*
— succincta, *Schloth.*
— gigantea, *Sow.*
Nucula navis, *Piette.*
Macrodon pullus, *Terqm.*
Inoceramus pinnæformis, *Dukr.*
Gervillia Hagenovii, *Dukr.*
Avicula Kurrii, *Oppel.*
Pinna Hartmanni, *Ziet.*
Modiola Hillana, *Sow.*
— nitidula, *Dukr.*
— scalprum, *Sow.*
Astarte obsoleta, *Dukr.*
Cardinia concinna, *Sow.*
— crassiuscula, *Sow.*
— Listeri, *Sow.*
Hippopodium ponderosum, *Sow.*
Unicardium cardioides, *Phill.*
Cardium Heberti, *Terqm.*
Protocardia Phillippiana, *Dukr.*
Isodonta elliptica, *Dukr.*
Tancredia securiformis, *Dukr.*
Cyrena Menkei, *Dukr.*
— Germari, *Dukr.*
Tæniodon ellipticus, *Dukr.*
Pholadomya corrugata, *Dukr.*
Goniomya heteropleura, *Agass.*
Gresslya Galathea, *Agass.*
Pleuromya subrufosa, *Dukr.*
— liasina, *Schübl.*

The Planorbis-beds are developed in Württemberg, and exposed near Stuttgart; at Rüdern smooth forms of *Aegoceras planorbis* lie in a dark crystalline limestone; and at Nellingen, the smooth and plaited varieties of the same species are found together in a dark-grey limestone.

In Swabia they are likewise worked, and from them a fine series of Ammonites have been collected by Professor Quenstedt, which are contained in the Tübingen University

Museum. The *A. planorbis* of the Lias *a*, near Tübingen, very much resembles the variety of this shell found clustered together in blocks washed out of the Scar at Robin Hood's Bay. One of the finest specimens of this locality, in the Leckenby Collection, Woodwardian Museum, Cambridge, I have figured as typical of the species.

In Baden the Planorbis-beds are found in the Langenbrücker Jura resting upon the Bone-bed Sandstone of the CONTORTA series, and containing shells and fishes' remains similar to those found in England. The lower Lias begins at Malsch and Oestringen with a 2-foot bed of black-blue Limestone containing *Aegoceras planorbis*. The ANGULATUM zone appears to be absent, for the Planorbis-bed is overlain by clay containing *Gryphæa arcuata* and Fucoids, upon which rests the *Bucklandi*-series.

In France this zone is well developed in the department of the Côte d'Or, as proved by the following list of fossils obtained from the Lumachelle de l'Auxois,[1] and contained in the well-arranged Museum of Semur, all of which I had the advantage of studying under the polite guidance of MM. Collenot and Bréon, to whose scientific knowledge, judgment, and good taste, this fine local collection owes its well-merited reputation.

REPTILES.

Ichthyosaurus, *sp.*, at Beauregard, Semur.

FISHES.

Saurichthys acuminatus, *Agass.*

Sargodon tomicus, *Plien.*

CEPHALOPODA.

Aegoceras planorbis, *Sow.*
— Johnstoni, *Sow.*
— tortile, *d'Orb.*

Aegoceras Prometheus.
— laqueus, *Quenst.*
— Burgundiæ, *Mart.*

GASTEROPODA.

Chemnitzia Phidias, *d'Orb.*
Neritina cannabis, *Terq.*
Littorina clathrata, *Desh.*
Turritella Deshayesei, *Terq.*

Pleurotomaria, *sp.*
Cerithium, *sp.*
Orthostoma, *sp.*
Turbo, *sp.*

LAMELLIBRANCHIATA.

Pleuromya crassa, *Agass.*
— striatula, *Agass.*
Pholadomya prima, *Quenst.*
Goniomya Sinemuriensis, *Opp.*
Anatina Sinemuriensis, *Mart.*
Leda tenuistriata, *Piett.*
Astarte Geuxii, *d'Orb.*
— cingulata, *Terq.*

Cypricardia compressa, *Terq.*
Cardita tetragona, *Terq.*
Cardinia Sinemuriensis, *d'Orb.*
— Deshayesei, *Terq.*
— quadrangularis, *Mart.*
— Moreana, *Mart.*
— crassiuscula, *Sow.*
— trapezium, *Mart.*

[1] J. J. Collenot, 'Description Géologique de l'Auxois,' p. 209.

Cardinia Hennoquii, *Terq.*
— Collenoti, *Mart.*
— subovalis, *Mart.*
— brevis, *Mart.*
— Breoni, *Mart.*
— concinna, *Sow.*
— contracta, *Mart.*
— trigona, *Mart.*
— Listeri, *Sow.*
— hybrida, *Stutch.*
— ovum, *Mart.*
Lucina arenacea, *Terq.*
Tancredia Sinemuriensis, *Mart.*
— Deshayesei, *Terq.*
Cucullæa similis, *Terq.*
Arca Collenoti, *Mart.*
— Hettangiensis, *Mart.*
Pinna semistriata, *Terq.*
Mytilus minutus, *Goldf.*
— Geuxii, *d'Orb.*
— rusticus, *Terq.*
Saxicava, *sp.*
Lima edula, *d'Orb.*
— Valoniensis, *Defrance.*
Lima Hettangiensis, *Terq.*
— pectinoides, *Sow.*
— prælonga, *Mart.*
— tuberculata, *Terq.*
— duplicata, *Quenst.*
Avicula Deshayesei, *Terq.*
— infraliasina, *Mart.*
— Dunkeri, *Terq.*
— Sideloci, *Mart.*
— similis, *Piet. et Terq.*
Inoceramus, *sp.*
Pecten pollux, *d'Orb.*
— calvus, *Goldf.*
— dispar, *Terq.*
Gervillia acuminata, *Terq.*
Plicatula spinosa, *Sow.*
— Deslongchampsei, *Piet. et Terq.*
— Hettangiensis, *Terq.*
— intustriata, *Emmr.*
— Baylii, *Terq.*
Hinnites liasinus, *Terq.*
Ostrea marcignyana, *Mart.*
— irregularis, *Münst.*
— læviuscula, *Munst.*

Brachiopoda.

Spiriferina Walcotii, *Sow.*
Terebratula perforata, *Piet.*

Echinodermata.

Pentacrinus angulatus, *Opp.*
Ophioderma, *sp.*
Cidaris Martini, *Cott.*
Hemipedina Burgundiæ, *Cott.*

Anthozoa.

Septastræa excavata, *De From.*
Isastræa basaltiformis, *De From.*
Astrocœnia sinemuriensis, *De From.*
Stylastræa Sinemuriensis, *De From.*
— Martini, *De From.*

In addition to the above fossils there are upwards of forty species of Foraminifera from the zone of *A. planorbis* at l'Auxois (see the description of " Les Foraminifères de l'Auxois " in the memoirs of M. Terquem).

The zone of *A. planorbis* was likewise found by Dr. Reynès in the Aveyron; and in the Ardêche at Mercuer, near Aubenas, by M. Ch. Laforêt, where he collected both the smooth and plaited varieties of *A. planorbis* in the same bed.

2. The Zone of Aegoceras Angulatum.

Synonyms.—"Sandige Kalke und Sandsteine mit *Am. angulatus*, Quenst.," 'Flötzgeb.,' p. 541, 1843. "Grès infraliasique" (pars), Dufrénoy et De Beaumont. 'Exp. Carte Geol. France,' vol. ii, p. 157, 1848. "Grès liasique, grès de Hettange," Terquem, 'Paléont. du Dép. de la Moselle,' p. 11, 1855. "Die Schichten des *Ammonites angulatus*," Oppel, 'Juraformation,' p. 28, 1856. "Zone à *Ammonites Moreanus*," Martin, "Pal. Stratigraph. de l'Infra-lias du Départ. de la Côte-d'Or," 'Mém. Soc. Géol. de France,' p. 38, 2nd série, 1860. "Augulatenschicten," Seebach, "Der Hannoversche Jura," p. 17, 1864. "Die Angulatenschichten die untere Jura," Brauns, p. 70, 1871. "Zone d'*A. angulatus*," Dumortier, 'Études de Bassin de Rhone,' Prem. Pt., p. 100, 1864. "Zone of *Ammonites angulatus*," Tate and Blake, 'Yorkshire Lias,' p. 46, 1876.

The *Angulatum*-zone, so far as it has been exposed, appears to be imperfectly developed in the Midland Counties, and from the difficulty experienced in separating its beds from the *Bucklandi*-series, they were grouped with the latter in my memoir.[1] On the Continent, however, and especially in France, this zone forms a very important horizon, and contains a rich fauna. M. Jules Martin,[2] in his valuable memoir on the Infra-Lias of the department of the Côte-d'Or, says, "this zone forms one of the best characterised palæontological horizons in the Côte-d'Or, and contains the richest and most varied fauna. Limited to two or three yards in thickness, this deposit appears to correspond to a period of animalisation of admirable fecundity. It is from these that we have collected the charming fauna which we last year indicated, and which has such intimate relations with the Hettangian fauna described by M. Terquem." From this zone M. Martin has collected and catalogued—1 *Ichthyosaurus*, 1 *Ichthyodorulite*, 10 sp. of *Cephalopoda*, 63 sp. of *Gasteropoda*, 77 sp. of *Conchifera*, 5 sp. of *Brachiopoda*, 4 sp. of *Echinodermata*, 10 sp. of *Anthozoa*, 3 sp. *Annelida*, and the débris of *Crustacea*. In the Department of the Moselle M. Terquem[3] has enumerated 177 species from the same zone. *Aegoceras angulatum*, (Schloth.), is found between Charmouth and Lyme Regis, in dark shale, below the grey concretionary limestone, with a mammilated surface; and likewise in the same strata south-west of the Cob. From these beds I have collected *Aegoceras angulatum* (Schloth.), *Aeg. Moreanum* (d'Orb.).

This zone was well exposed in the Harbury cutting of the Great Western Railway, near Warwick, although very few Mollusca besides *Aegoceras angulatum* were obtained therefrom; on the spoil-banks, even now, some good fragments are occasionally found. On the coast of Yorkshire it occurs near Redcar, where it has been studied with much care by Messrs. Tate and Blake, and they have given a detailed account of its beds in their excellent work on the 'Yorkshire Lias,' p. 48, whence the following section is derived :—

[1] 'Quart. Journ. Geol. S.,' xvi, p. 398, 1860.

[2] 'Paléontologie stratigraphique d'Infra-Lias du département de la Côte-d'Or,' p. 39, 1860. 'Mém. Soc. Géol. de France,' 2nd série, tom. vii, Mém. No. 1.

[3] 'Paléontologie du département de la Moselle,' p. 12, 1855.

Section of the Angulatum-beds at Redcar (Yorkshire).

No.	Lithology.	Thickness. ft.	in.	Organic Remains.
1	Base of the lowest scar of the *Bucklandi* zone	—		*Arietites Conybeari, Lima gigantea, Pentacrinus.*
2	Blue shale with a line of *Am. Conybeari* at the depth of 1 foot	2	8	*Cardinia Listeri, Gryphæa arcuata, Lucina limbata, Pentacrinus.*
3	Indurated shale 5 inches, earthy limestone 1 inch	2	6	*Aegoceras angulatum, Gryphæa* (small). *Unicardium cardioides.*
4	Blue shale			*Aeg. angulatum.*
5	Friable shale, Oyster bed, and irregular limestone nodules 1½ inches	0	7	*Aeg. angulatum, Pleurotomaria similis, Dentalium Etalense, Astarte Oppeli, Lima gigantea, Cardinia Listeri, Pleuromya crassa, Serpula socialis.*
6	Blue shale	1	0	*Aeg. angulatum* (large size), *Gryphæa.*
7	Friable shale, with Oysters chiefly, 2 inches	0	5	*Aeg. angulatum, Cardita Heberti, Lucina limbata, Plicatula liasina.*
8	Blue shale			*Terquemia arietis, Perna infraliassica, Rhyn. plicatissma, Montlivaltia polymorpha.*
9	Band of small Gryphæa, ½ inch; blue shale	3	0	*Aeg. angulatum, Plicatula liasina.*
10	Shell band and shelly limestone, 1½ inch; irregular, 5 inches. Blue shale	6	4	*Aeg. angulatum, Eucyclus elegans, Astarte obsoleta.*
11	Shelly limestones, sometimes Encrinital, with shale, 2½ inches	2	8	*Aeg. angulatum, Encyclus acuminatus.*
12	Blue shale			
13	Coral bed: a friable shale with small pebble-like concretions at top, very fossiliferous, 2½ inches	2	0	*Aeg. angulatum, Astarte Oppeli, Cardita Heberti, Plicatula liasina, Pleurot. similis, Montlivaltia Haimei, Serpula socialis, Waldheimia Sarthacensis.*
14	Depressed, irregular limestone doggers, 1½ inch			
15	Shale with *Gryphæa arcuta*			*Aegocras angulatum* (large).
16	Earthy subcrystalline limestone	1	2	*Aeg. angulatum* (large).
17	Black smooth shale			
18	Friable shale and Oyster band	0	6	
19	Smooth shale			
20	Siliceous limestone, ½ inch	0	6	
21	Smooth shale			
22	Limestone doggers, depressed			*Lima gigantea.*
23	Thin shell limestone			
24	Friable shale	3	2	
25	Smooth shale, 9 inches			*Aeg. angulatum.*
26	Earthy limestone or doggers	0	2	*Cardinia ovalis.*
27	Smooth shale	1	0	
28	Blue siliceous limestone	0	1	*Ostrea ungula, Dentalium Etalense.*
29	Friable shale	0	8	*Aeg. angulatum.*
30	Siliceous limestone	0	2	
31	Friable shale	1	5	*Aeg. angulatum.*

Palæontology.—The Angulatum-beds in the Department of Côte-d'Or have yielded a very rich fauna to the researches of M. Martin; many of these fossils were described and figured in the memoir already cited, and MM. Terquem and Piette have made like

contributions to the history of the fauna of this zone in their valuable monograph, "Le Lias inférieur de l'Est de la France."[1] The researches of MM. Tate and Blake in the Yorkshire Lias have added much to our knowledge of the British fossils of the Angulatum-beds near Redcar, as the following list shows.

Fossils from the Angulatum-Zone.

Reptilia.

Ichthyosaurus, vertebræ and teeth.

Plesiosaurus, vertebræ and teeth.

Pisces.

Hybodus minor, *Agass.*

Acrodus minimus, *Agass.*

Cephalopoda.

Aegoceras angulatum, *Schl.*
— Johnstoni, *Sow.*
— Liasicum, *d'Orbigny.*

Aegoceras nanum, *Mart.*
Nautilus striatus, *Sow.*
Belemnites infundibulum, *Phillips.*

Gasteropoda.

Discohelix striata, *Piette.*
— semiclausa, *Tate.*
Pleurotomaria obesula, *Tate.*
— similis, *Sow.*
— tectaria, *Tate.*
Pitonellus sordidus, *Tate.*
Cryptænia solarioides, *Sow.*
— rotellæformis, *Dunker.*
— nucleus, *Terquem.*
Cerithium gratum, *Terquem.*
— Semele, *d'Orbigny.*
— spiratum, *Moore.*
Dentalium Etalense, *Terquem.*

Dentalium limatulum, *Tate.*
Actæonina fragilis, *Dunker.*
Phasianella Morencyana, *Piette.*
Turbo solarium, *Piette.*
— philemon, *d'Orbigny.*
Littorina semiornata, *Münst.*
Eucyclus elegans, *Münster.*
— acuminatus, *Chap. & Dewal.*
Turritella Dunkeri, *Terquem.*
Chemnitzia transversa, *Blake.*
— Berthandi, *Dunker.*
— unicingulata, *Terquem.*
— Etalensis, *Piette.*

Lamellibranchiata.

Ostrea ungula, *Münster.*
— semiplicata, *Münster.*
Gryphæa arcuata, *Lamarck.*
Anomia alpina, *Winkler.*
— striatula, *Oppel.*
Plicatula liasina, *Terquem.*
Pecten calvus, *Goldfuss.*
— punctatissimus, *Quenstedt.*
— textilis, *Münster.*
— textorius, *Schlotheim.*

Limea Blakeana, *Tate.*
Avicula Pattersoni, *Tate.*
Perna infraliasica, *Quenstedt.*
Pinna Hartmanni, *Zieten.*
Macrodon pullus, *Terquem.*
— Hettangiensis, *Terquem.*
— navicula, *Terquem.*
Leda Galathea, *d'Orbigny.*
— Renevieri, *Oppel.*
— texturata, *Terquem.*

[1] 'Mémoires de la Société Géologique de France,' 2e série, tome viii, p. i, 1865.

Leda v-scripta, *Tate.*
Nucula nævis, *Piette.*
Astarte obsoleta, *Dunker.*
— cingulata, *Terquem.*
— Oppeli, *Andler.*
Hippopodium ponderosum, *Sow.*
Cardita Heberti, *Terquem.*
Protocardia Phillipiana, *Dunker.*
Cardinia crassiuscula, *Sow.*
— ovalis, *Stutchburg.*
— Deshayesii, *Terquem.*
— Desoudini, *Terquem.*
Cardinia Listeri, *Sow.*
Lucina limbata, *Terquem.*
Modiola hillanoides, *Chap. & Dewalq.*
— lævis, *Sow.*
— Hillana, *Sow.*
Saxicava arenicola, *Terquem.*
Myoconcha psilonoti, *Quenstedt.*
— inclusa, *Terquem.*
Unicardium cardioides, *Phillips.*
Pholadomya glabra, *Agassiz.*
Gresslya Galathea *Agassiz.*
Pleuromya crassa, *Agassiz.*

Brachiopoda.

Waldheimia Sarthacensis, *d'Orbigny.*
Spiriferina rostrata, *Schlotheim.*
Rhynchonella plicatissima, *Quenstedt.*

Crustacea.

Bairdia liasica, *Brodie.*
— lacryma, *Blake.*
— Redcarensis, *Blake.*
— elongata, *Blake.*
Polycope cerasia, *Tate.*
Cythere Blakei, *Jones.*
— circumscripta, *Blake.*
— paupercula, *Blake.*
— Redcarensis, *Blake.*
— arcuformis, *Blake.*

Annelida.

Ditrypa capitata, *Phill.*
— globiceps, *Quenst.*
Galeolaria socialis, *Goldf.*
Serpula limax, *Goldf.*
— plicatilis, *Goldf.*
— flaccida, *Goldf.*

Echinodermata.

Cidaris Edwardsii, *Wright.*
Hemipedina Tomesi, *Wright.*
Pentacrinus psilonoti, *Quenst.*
— basaltiformis, *Müller*

Anthozoa.

Septastræa excavata, *de From.*
Montlivaltia Haimei, *Chap. & Dewalq.*
Montlivaltia polymorpha, *Terquem.*

Foreign Correlations.—Professor F. A. Römer, in 1836,[1] published an important work on the 'Jurassic Formations of North Germany,' which formed the starting-point of numerous observations made since that date by several accurate observers, as Dr. U. Schlönbach, "Ueber den Eisenstein des mittleren Lias im nordwestlichen Deutschland," as developed at Harzburg, Liebenburg near Goslar, Bodenstein, Calefeld, and other places;[2] also Professor von Seebach, "Der Hannoversche Jura;"[3] and Emerson, "Der Liasmulde von Markoldendorf bei Einbeck."[4] After a careful examination of the

[1] 'Die Versteinerungen des Nord-deutschen Oolithen-Gebirges,' 1836.
[2] 'Zeitschr. d. d. Geol. Ges.,' Band xv, p. 465, Jahrg., 1863.
[3] 'Der Hannoversche Jura,' mit 10 Tafeln und 1 Karte, 1864.
[4] 'Zeitschr. d. d. Geol. Ges.,' Band xxii, p. 271, 1870.

organic remains and an accurate determination of the species, each of these authors has placed the strata of the Lower and Middle Lias in their proper zones. Similar studies had been well and carefully carried out by previous observers with like results, as Bornemann, Strombeck, Ulrich, Ewald, Rolle, Wagener, &c., and from the united Palæontological data thus obtained we have learned the correlation of the north-west German Lias beds, as shown in the following table—

The Middle and Lower Lias of North Germany.

Von Seebach.	Schlönbach.	Emerson.
	MIDDLE LIAS.	
Amaltheenthone.	Zone of *Am spinatus.*	Beds with *Am. spinatus.*
	Upper zone of *Am. margaritatus.*	Absent.
Beds with *Am. capricornus.*	Upper zone of *Am. fimbriatus.* Lower zone of *Am. margaritatus.*	Absent.
Beds with *Am. brevispina.*	Lower zone of *Am. fimbriatus.*	Beds with *Am. centaurus.*
	Zone of *Am. Jamesoni.*	Beds with *Am. brevispina.*
		Beds with *Terebratula subovoides* and *Am. armatus.*
	LOWER LIAS.	
Beds with *Am. planicosta.*	Zone of *Am. planicosta.*	Beds with *Am. bifer.*
		Beds with *Am. planicosta.*
Arietenschichten.	Zone of *Am. geometricus.*	Beds with *Am. geometricus.*
	Zone of *Am. Bucklandi.*	Absent.
Angulatenschichten.	Zone of *Am. angulatus.*	Beds with *Am. angulatus.*
Psilonotenschichten.	Zone of *Am. Johnstoni.*	Psilonotenschichten.
Rhætic.	Zone of *Avicula contorta.*	Avicula.

The Angulatum-zone, as shown in this table, is well developed in North Germany, as is proved by the valuable works of the late Professor U. Schlönbach and " Der untere Jura " of Dr. Brauns, from which it appears that many of the organic remains of the Planorbis-beds pass into the Angulatum-zone, and that it is difficult to draw a divisional line between them. The following list affords a correct idea of the Molluscan fauna of the North-German Angulatenschichten.

Cephalopoda.

Aegoceras angulatum, *Schlotheim.*
Nautilus intermedius, *Sow.*

Gasteropoda.

Hydrobia Krausseana, *Dkr.*
Turritella Zenkeni, *Dkr.*
Mesalia turritella, *Dkr.*
Pleurotomaria Anglica, *Sow.*
Pleurotomaria rotellæformis, *Dkr.*
Cylindrites fragilis, *Dkr.*
Dentalium Etalense, *Terq.* et *Piette.*
Discohelix pygmæa, *Dkr.*

Lamellibranchiata.

Ostrea sublamellosa, *Dkr.*
Gryphæa arcuata, *Lamk.*
Pecten textorius, *Schlth.*
Lima pectinoides, *Sow.*
Leda Renevieri, *Opp.*
Macrodon pullus, *Tqm.*
Inoceramus pinnæformis, *Dkr.*
Gervillia Hagenovii, *Dkr.*
Avicula inæquivalvis, *Sow.*
Pinna Hartmanni, *Ziet.*
Modiola Hillana, *Sow.*
— nitidula, *Dkr.*
— scalprum, *Sow.*
Astarte obsoleta, *Dkr.*
Cardinia concinna, *Sow.*
— crassiuscula, *Sow.*
— Listeri, *Sow.*
Unicardium cardioides, *Phill.*
Cardium Heberti, *Tqm.*
Protocardia Phillippiana, *Dkr.*
Isodonta elliptica, *Dkr.*
Pholadomya corrugata, *Dkr.*
Goniomya heteropleura, *Agass.*
— subrugosa, *Dkr.*
— liasina, *Schübl.*
Gresslya Galathea, *Agass.*

Echinodermata.

Pentacrinus, sp. Hypodiadema lobatum, *Desor.* Cidaris, sp.

The Angulatum-beds are well developed in Württemberg; and the Stuttgart Museum contains a very fine series of the leading fossils, as *Aegoceras angulatum, A. Moreanum, A. compressum, A. Liasicum,* and many other Mollusca. Some of the Ammonites are upwards of one foot in diameter, and were collected from the Lias *a* near that town. I have one nearly as large sent me by my esteemed friend Prof. Fraas.

In France this zone is found in several Departments, as in the Côte-d'Or, and is remarkable for the very rich fauna it has yielded to the researches of M. Martin and MM. Collenot and Bréon. In this zone likewise are found, in the Commune of Thoste, and at the hamlet of Beauregard, the remarkable ferruginous beds which have yielded such an immense quantity of Cardinias. These shells are in admirable preservation, fossilized by iron, and present all the characters of their internal structure. The Ammonites

Aeg. Moreanum, d'Orb., and *Aeg. catenatum*, Sow., *Aeg. Liasicum*, d'Orb., *Aeg. laqueum*, Quenst., *Aeg. angulatum*, Schloth., *Aeg. Charmassei*, d'Orb.

The workmen call the bed "Foie de Veau," and M. Martin[1] has adopted the local name as equivalent to his Zone à *Ammonites Moreanus*, of which he has given an exhaustive account in the memoir. M. Collenot[2] has likewise given a most able account of the zone, with very full details of the Mine at Beauregard, and has very carefully noted all the fossils that appertain to the "Foie de Veau," and placed them in separate cases in the Museum of Semur, where I had the opportunity of examining them, and has given the following list thereof in his exhaustive 'Description Géologique de l'Auxois.'

Reptiles.

Ichthyosaurus, sp.

Cephalopoda.

Aegoceras Liasicum, *d'Orb.*
— laqueum, *Quenst.*
— angulatum, *Schloth.*
— Moreanum, *d'Orb.*
Aegoceras Charmassei, *d'Orb.*
— Delmasi, *Reynés.*
— Hettangiense, *Terqm.*
Nautilus striatus, *Sow.*

Gasteropoda.

Littorina clathrata, *Desh.*
Turritella Deshayesea, *Terq.*
— Humberti, *Mart.*
— Dunkeri, *Terq.*
Melania cyclostoma, *Terq.*
— crassilabrata, *Terq.*
Tornatella acuminata, *Piet.*
Orthostoma turgidum, *Terq.*
— frumentum, *Terq.*
— oryza, *Terq.*
— decoratum, *Mart.*
— exile, *Mart.*
— gracile, *Mart.*
Trochus sinistrorsus, *Desh.*
— nitidus, *Terq.*
— lineatus, *Mart.*
Turbo decoratus, *Mart.*
— cristatus, *Mart.*
— philemon, *d'Orb.*
— Piettei, *Mart.*
— subcrenatus, *Mart.*
— nanus, *Mart.*
— selectus *Chap.* et *Dewal.*
Turbo triplicatus, *Mart.*
— Andleri, *Mart.*
— intextus, *Mart.*
Solarium lenticulare, *Terq.*
Straparolus Oppeli, *Mart.*
Pleurotomaria Terquemi, *Mart.*
— concava, *Mart.*
— Martiniana, *d'Orb.*
— rotelliformis, *Dunk.*
Purpurina tricarinata, *Mart.*
Trochotoma clypeus, *Terq.*
Cerithium verrucosum, *Terq.*
— Semele, *d'Orb.*
— subnudum, *Mart.*
— Martinianum, *d'Orb.*
— Sinemuriense, *Mart.*
— Arduennense, *Piet.*
— gratum, *Terq.*
— Henrici, *Mart.*
— acuticostatum, *Terq.*
— Deshayesei, *Piet.* et *Terq.*
— Collenoti, *Mart.*
— trinodulosum, *Mart.*

[1] 'Paléontologie stratigraphique de l'Infra-Lias de Département de Côte d'Or,' p. 38, 1860.

[2] 'Description géologique de l'Auxois,' p. 219, 1873.

Lamellibranchiata.

Leda Aballoensis, *Mart.*
Cardita Heberti, *Terq.*
Astarte consobrina, *Chap.* et *Dewal.*
Cardinia Listeri, *Sow.*
— sublamellosa, *d'Orb.*
— acuminata, *Mart.*
— hybrida, *Agass.*
— exigua, *Terq.*
Lucina arenacea, *Terq.*
Cardium Terquemi, *Mart.*
Nucula Sinemuriensis, *Mart.*
Arca pulla, *Terq.*
— Sinemuriensis, *Mart.*
Pinna Hartmanni, *Ziet.*
— semistriata, *Terq.*
Avicula Sinemuriensis, *d'Orb.*
Mytilus Guexii, *d'Orb.*
— rusticus, *Terq.*
Lima edulis, *d'Orb.*
— gigantea, *Sow.*
— Hettangiensis, *Terq.*
Ostrea irregularis, *Münst.*

Brachiopoda.

Terebratula perforata, *Piet.*
— retusa, *Mart.*
Rhynchonella variabilis, *d'Orb.*
— plicatissima, *Quenst.*

Echinodermata.

Pentacrinus tuberculatus, *Mill.*
Astropecten, *sp.*

Anthozoa.

Montlivaltia Martini, *de From.*
— Sinemuriensis, *d'Orb.*
Thecosmilia Martini, *de From.*
Isastræa Sinemuriensis, *de From.*
Stylastræa Martini, *de From.*
Astrocœnia Sinemuriensis, *de From.*

Spongiaria.

Porosmilia Martini, *de From.*
Amorphofungia Dumortieri, *Mart.*

Foraminifera.

Placopsilina Flouesti, *Terq.*
Involutina petrea, *Terq.*

The Lower Lias is well developed in the Departments of the Meurthe and the Moselle, in the east of France, in the Grand Duchy of Luxembourg, Belgium, and in the Dep. Meuse. The fossils, from its different zones, have been collected with great care, and their species determined, beautifully figured, and well described by MM. O. Terquem and Ed. Piette in their valuable memoir.[1] In the valley of the Moselle a great number of Mollusca have been discovered in the large quarries of the Angulatum-beds, "Le grès d'Hettange," which has become famous for its fossil riches. The authors enumerate 15 species of plants and 332 species of animals from the zone of *Aeg. angulatum*. Of this total 53 are found in the Planorbis-beds, 212, or two thirds, pass into the upper zones, and 120

[1] "Le Lias inférieur de l'est de la France," 'Mém. de la Soc. Géol. de France,' 2e série, tome viii, 1865.

species appear to be special to the zone of *Aeg. angulatum*, nearly all of which are represented in the "Grès d'Hettange."

In Luxembourg the Marne de Jamoigne represents the Angulatum-zone, and beds of the same age are found in the valleys of the Semois, the Chiers, and the Meuse. In Gloucestershire I have seen small specimens, which were found near Aust and Gloucester. This zone is likewise exposed in the north of Ireland, in the remarkable Lias district near Portrush.

3. The Zone of Arietites Bucklandi.

Synonyms.—"Blue Lias," William Smith, 'Memoir to the Map,' 1815. "Blue Lias Limestone," De la Beche, 'Geol. Trans.,' 2nd series, vol. ii, 1829. "Gryphiten-Kalkstein," Alberti, 'Die Gebirge des König. Württemberg,' p. 121, 1826. "Liaskalk," Mandelsloh, 'Geol. Profile der schwäbisch. Alpen,' p. 28, 1834. "Calcaire à Gryphites" (pars), Dufrénoy et de Beaumont, 'Mém. Soc. Géol. de France,' p. 196, 1830. "Grès de Luxembourg" (pars. sup.), Omalius d'Halloy, 'Élém. de Géologie,' p. 375, 1835. "Grès de Luxembourg," Dewalque, 'Descrip. du Lias de la Luxembourg,' p. 28, 1857. "Plagiostoma-beds, Lower Lias," Murchison, 'Geol. of Cheltenham,' 2nd ed., p. 49, 1845. "Arietenkalk," Quenstedt, 'Der Jura,' Table, p. 293, 1857. "Die Schichten des Ammonites Bucklandi," Oppel, 'Juraformation,' p. 35, 1856. "Zone of *Ammonites Bucklandi*," Wright, 'Quart. Jour. Geol. Soc.,' vol. xvi, p. 398, 1860. "Zone de l'*Ammonites Bucklandi*," Dumortier, 'Études Paléont. sur les Dépôts Jurassiques du Bassin du Rhone,' 2e part, p. 6, 1867. "Die Arietenschichten," Brauns, 'Der untere Jura,' p. 78, 1871. "Zone of Ammonites Bucklandi," Tate and Blake, 'Yorkshire Lias,' p. 54, 1876.

The *Bucklandi*-zone forms an important subdivision of the Lower Lias. This series attains a great development in the midland counties and in Glamorgan, Dorset, and Somerset. The rocks are characterised throughout by the prevalence of a number of large *Ammonites* belonging to the natural group *Arietes* (von Buch), and by many *Lamellibranchiata* of the genera *Lima* and *Gryphæa*. In England it everywhere consists of beds of grey-bluish argillaceous limestone, interstratified with bands of marl, shale, and clay of a similar colour. In some parts of the counties of Warwick, Somerset, Dorset, and Glamorgan this series attains a thickness of 80 feet.

Gloucestershire and Somersetshire.—In Gloucestershire it was exposed in the deep cutting of the Dean Forest Railway at Highnam, and is seen in the Lias limestone-quarries near Tewkesbury, and in the natural escarpments at Frethern and Purton-on-the-Severn. In Somersetshire it was sectionised in making the Great Western Railway between Bristol and Bath, and probably at no point were the several beds of the *Lima* series better shown than in the cutting at Saltford, seven miles from Bristol. My late

friend, Mr. William Sanders, F.R.S., made the following profile during the execution of the work, which, together with his notes on the fossils contained in the different strata, have been kindly communicated by my friend, Mr. Etheridge, F.R.S. This section is of great value, inasmuch as the beds are now partially concealed by *débris* and vegetation, and the characteristic fossils are no longer found in their respective beds.

Section of the Bucklandi-Beds at Saltford, near Bath, Great Western Railway.[1]

No.	Lithology.	Thickness.	Organic Remains.
		feet.	
	Brown gravelly marl	120	
	Beds of laminated shale and clay	110	
	Dark clay, with boulders, and layers of septaria at the top and bottom of the bed, and in the clay between.....	105	Scales of *Tetragonolepis monilifer*, Agass., and *Belemnites acutus*, Mill.
59	Grey Lias limestone.....	100	*Rhynchonella variabilis*, Schloth.
58	Dark shale		*Belemnites acutus*, Mill.
	Grey Lias limestone.		
	Dark shale		*Ostrea Goldfussi*, Bronn, *Avicula calva*, Schlön., and *Pecten textorius*, Schlot.
57	Grey Lias limestone.....		*Arietites Conybeari*, Sow., and *Belemn. acutus*, Mill.
	Dark shale.		
56	Thin limestone-band.		
	Dark limestone.....		*Nautilus striatus*, Sow., *Ariet. Conybeari*, Sow., and *Belemnites acutus*, Mill.
55	Grey Lias limestone.....	95	*Lima gigantea*, Sow., and *Spiriferina Walcotti*, Sow.
	Dark limestone.		
54	Grey Lias limestone.		
	Dark shale.		
53	Grey Lias limestone.		
	Dark laminated shale.		
52	Dark grey Lias limestone.....		Vertebræ of *Ichthyosaurus*, *Ar. Bucklandi*, Sow., and *Spiriferina Walcotti*, Sow.
	Dark shale		*Ar. Bucklandi*, Sow., *Nautilus striatus*, Sow., and *Spiriferina Walcotti*, Sow.
51	Grey Lias limestone.....	90	
	Dark shale.		
50	Grey Lias limestone.....		*Hybodus curtus*, Agass.
	Dark shale		*Pholadomya glabra*, Agass.
49	Grey Lias limestone.....		*Nautilus striatus*, Sow. (large), *Ar. Brookii*, *Sow.*, and fossil wood.
	Dark shales		*Ar. Conybeari*, Sow., and *Ar. Bucklandi*, Sow.
48	Grey Lias limestone.....		*Pleurotomaria similis*, Sow., and *Lima gigantea*, Sow.
	Dark shales		*Ar. Bucklandi*, Sow., and *Pleurotomaria similis*, Sow.
47	Grey Lias limestone.		
	Dark shales		*Arietites Conybeari*, Sow.
46	Grey Lias limestone.....		*Nautilus striatus*, Sow.

[1] This section shows the relative position of the zones of *Ar. Bucklandi*, *Aeg. planorbis*, and *Avicula contorta* in this part of the county, and affords a good type for comparing these three stages in Somersetshire with the same groups in other parts of the south of England.

No.	Lithology.	Thickness.	Organic Remains.
		feet.	
	Dark shales		*Pentacrinus tuberculatus*, Mill. (stem), and *Pecten textorius*, Schloth.
45	Dark-grey limestones		*Ichthyosaurus communis*, Conyb.
	Dark shales		*Gryphæa arcuata*, Lamk., and *Pentacrinus tuberculatus*, Mill.
44	Grey limestone.		
	Dark shales.		
43	Grey limestone		*Ichthyosaurus communis*, Conyb., and *Ar. Conybeari*, Sow.
	Dark shales		*Pinna Hartmanni*, Ziet., and *Gryphæa arcuata*, Lamk.
42	Bluish limestone	80	
41	Thirteen or fourteen limestone bands, with irregular surfaces; some nodular, with partings of clay and shale	75	*Pholadomya glabra*, Ag., and *Lima pectinoides*, Sow., *Gryphæa arcuata*, Lam., and *Rhynchonella variabilis*, Schl.
40	From sixteen to eighteen beds, comprising 20 inches of stone.....	70	*Pholadomya glabra*, Ag., and *Lima gigantea*, Sow.
39	Fourteen beds of limestone and clay ...		*Pecten textorius*, Schl. *Pholadomya glabra*, Ag., and *Pleurotomaria similis*, Sow.
38	Eight beds of limestone and clay		*Lima pectinoides*, Sow., and *Cardinia ovalis*, Stutch.
37	Thirteen beds of limestone and clay; the limestones irregular, water-worn, and nodular	65	*Pholadomya glabra*, Ag., *Rhynchonella variabilis*, Schl., and *Ostrea Goldfussi*, Bronn.
	Dark laminated shales		*Ostrea Goldfussi*, Bronn.
36	Grey limestone.		
	Dark shales.		
35	Greyish limestone	60	
34	Ten beds of shales and limestone; septaria in the lower beds.		
33	Thin grey limestone.		
	Thick dark clay.		
32	Thin band of limestone.		
	Dark clay.		
31	Thin band of limestone	50	
	Thick dark shales.		
30–25	Six beds of limestone, alternating with six thicker beds of clay	43	
24	Light-coloured limestone.		
	Dark-coloured shale.		
23	Light-coloured limestone.		
	Dark shale.		
22	Thick White Lias	40	
21–11	Twelve beds of White Lias, separated by 12 thin bands of clay.....	35	*Pinna Hartmanni*, Ziet., and *Unicardium cardioides*, Phil.
	10. Four beds of limestone, becoming thin and rubbly beneath, and nodular at the base	30	*Pecten textorius*, Goldf., and *Pholadomya glabra*, Ag., *Modiola Hillana*, Sow., and *Avicula Sinemuriensis*, d'Orb.
9	Cotham marble or Landscape-stone.....		Forms the base of the White Lias series.

White Lias Series.

	No.	Lithology.	Thickness.	Organic Remains.
			feet.	
Avicula contorta Series.		Black shales.		
	8	Band of limestone	20	
	7	Nodular limestone.		
		Black shales	15	Fishes' scales; layers of compressed *Pullastra arenicola*, Strickl.
	6	Dark limestone.....	10	*Pecten Valoniensis*, Defr., and *Avicula contorta*, Portl.
		Dark shale.		
	5	Dark limestone		*Pullastra arenicola*, Strickl.
		Dark shale.		
	4	Greenish-brown soft marl.		
		Marlstone.		
	3	Pale-bluish clay, with plant-like fibres...	5	
	2	Buff-coloured clay.		
		Grey sandy marlstone, with ferruginous spots.		
		New Red Marl.		

Lyme Regis.—The *Bucklandi*-zone is admirably shown in the coast-section at Lyme Regis, Dorset, both in the Church Cliffs and at Pinhay Bay, where the beds consist of a series of grey limestones, from 2 to 10 inches in thickness, varying from earthy to compact, and alternating with marls and shaly beds—either in seams of a few inches, or in beds of many feet in thickness. The following section, from the lowest stratum on the shore to Broad Ledge, which may be considered the uppermost bed of the *Bucklandi* series, affords a correct view of the stratigraphical order of these strata at Lyme and of the fossils they contain. The profile must be read in a descending order through the *Turneri* and *Bucklandi* beds towards the *Angulatum*-zone on the shore.

Section of the Bucklandi-beds *from Broad Ledge to the shore at Lyme Regis.*

	No.	Lithology.	Thickness.	Organic Remains.
			ft. in.	
Turneri-beds.	1	Dark-grey limestone. "Broad Ledge" or "Table-bed"	3 6	*Ichthyosaurus communis*, Conyb., *I. platyodon*, Conyb., *Arietites semicostatus*, Y. & B., and *Rhynchonella variabilis*, Schloth.
	2	Dark marls and shales, with bands of clays	18 0	*Arietites Turneri*, Sow., and Fishes.
	3	Grey limestone.....	0 4	*Arietites Turneri*, Sow., and *Ar. semicostatus*, Y. & B.
	4	Dark slaty marls with indurated bands of imperfect limestone	3 0	*Lima gigantea*, Sow., *L. antiquata*, Sow.

No.	Pathology.	Thickness.	Organic Remains.
		ft. in.	
5	Dark-grey limestone	1 0	*Lima gigantea*, Sow., *L. antiquata*, Sow., and *Rhynchonella variabilis*, Schloth.
6	Black shales, with partings of gypsum	2 6	*Ichthyosaurus communis*, Conyb. (in the "fire-stone beds" west of the Cobb).
7	Dark-greyish limestone	0 10	*Lima gigantea*, Sow., *L. antiquata*, Sow., and *Rhynchonella variabilis*, Schloth.
8	Dark shale	2 0	*Gryphæa arcuata*, Lamk.
9	Hard grey limestone. "Grey Ledge"	1 3	Fin-spines of *Hybodus*, *Rhynchonella variabilis*, Schloth, and *Pentacrinus tuberculatus*, Mill.
10	Dark shaly marls	2 0	*Icthyosaurus platyodon*, Conyb.
11	Grey limestone	0 6	Spines of *Pseudo-diadema*, and other *Echinidæ*.
12	Dark indurated shale	3 6	*Ichthyosaurus platyodon*, Conyb.
13	Bluish limestone	1 0	*Gryphæa arcuata*, Lam., *Rhynchonella variabilis*, Schloth, and *Lima antiquata*, Sow.
14	Dark shales, containing indurated imperfect limestone	1 6	*Ichthyosaurus communis*, Conyb., *I. platyodon*, Conyb., *Pentacrinus tuberculatus*, Mill., and *Lima gigantea*, Sow.
15	Bluish limestone	0 10	
16	Dark indurated clay	1 3	*Gryphæa arcuata*, Lam., and fragments of *Pentacrinus tuberculatus*, Mill.
17	Grey limestone, with the plant-bed at the top	0 6	*Otopteris obtusa*, L. & H., and *Araucarites peregrinus*, Sternb., in the plant-bed.
18	Dark-bluish limestone	1 6	*Arietites Conybeari*, Sow., and *Rhynchonella variabilis*, Schloth.
19	Dark shale	0 8	*Gryphæa arcuata*, Lam.
20	Dark-greyish limestone	0 10	*Arietites Bucklandi*, Sow., and *Ar. rotiformis*, Sow.
21	Dark shale	0 8	
22	Grey limestone	0 4	
23	Dark shale	1 0	*Ichthyosaurus tenuirostris*, Conyb.
24	Dark greyish limestone	1 4	*Ichthyosaurus communis*, Conyb., skulls and bones of other species, with *Rhynchonella variabilis*, Schloth.
25	Hard shale, forming "Quick Ledge"	1 6	*Ichthyosaurus communis*, Conyb., and *I. intermedius*, Conyb.
26	Blue limestone	0 6	*Arietites Bucklandi*, Sow., and *Lima gigantea*, Sow.
27	Dark shale	0 8	*Gryphæa arcuata*, Lam., and *Rhynchonella variabilis*, Schloth.
28	Concretionary limestone (surface mammillated)	0 4	
29	Dark-grey shale	0 8	*Aegoceras angulatum*, Schloth.
30	Greyish limestone	0 6	*Lima gigantea*, Sow., and *L. antiquata*, Sow.
31	Dark indurated shale	0 9	*Aegoceras angulatum*, Schloth. (large specimens with small Gryphæa adherent). *Gryphæa arcuata*, Lam., small and dwarfed.
32	Hard grey limestone	0 7	*Lima gigantea*, Sow., and *L. antiquata*, Sow.

Bucklandi or *Lima*-beds.

The shingle of the shore covers the lower beds of the *Angulatum* series.

Coast of Glamorganshire.—In Glamorganshire there is an extensive exposure of the *Bucklandi*-beds for the distance of sixteen miles along the coast, from Penarth Head,

by Barry Island, Aberthaw, and Dunraven Castle, to the mouth of the River Ogmore, where the Lower Lias rests on highly inclined beds of Carboniferous Limestone. The strata laid bare by the sea are chiefly those containing *Lima gigantea* and *Gryphæa arcuata*. At Cowbridge the same stratigraphical condition is observed, and the Lower Lias is here seen resting on Carboniferous Limestone. At Penarth Head, however, the relation of the *Bucklandi* to the *Planorbis* and *Avicula contorta* beds is much better seen than at any other part of the Glamorganshire coast.

The Rev. J. E. Cross, F.G.S., has described the Lias beds of North-west Lincolnshire,[1] which have recently been laid open by the extension of railways and searchings for Ironstone, and from his interesting and instructive paper I have deduced the following results.

A generalised profile of the Lias beds of North-west Lincolnshire.

LINCOLNSHIRE OOLITIC LIMESTONE.

HORIZONS.	PETROLOGY.	PALÆONTOLOGY.
UPPER LIAS.	Blue shale with moulds of Ammonites of the falcifer type, 60 feet thick.	*Harpoceras serpentinum, Lytoceras cornucopiæ.*
MIDDLE LIAS MARLSTONE.	Hard, light grey limestone, weathering to brown Ironstone with Rhynchonellæ, 8 feet thick.	*Amaltheus spinatus, Avicula cygnipes, Terebratula punctata, Rhynchonella tetraedra, Spiriferina rostrata.*
MIDDLE LIAS. MARLS.	Blue clay with cement nodules throughout, containing *Aegoceras capricornus*, 66 feet thick.	*Aegoceras Henleyi = capricornum, Belemnites fraxillosus, Plicatula spinosa, Avicula inæquivalis, Nucula complanata, Lima acuticosta, Rhynchonella variabilis.*
MIDDLE LIAS. IRONSTONE.	The Ironstone Pecten-bed, crowded with shells, 4 feet thick.	*Aeg. armatum, Aeg. striatum, Belemnites elongatus, Cardium multicostatum, C. hybrida, Myacites unionides, Tancredia liassica, Pecten lævis,* in great numbers and of good size.
Oxynotus and *raricostatus* zones.	Blue Marls of the Lower Lias, containing different zones of life, 90 feet thick.	*Aegoceras Birchii, Amaltheus oxynotus, Arietites raricostatus, Aeg. Taylori, Aeg. Loscombi, Aeg. natrix, Belemnites paxillosus, B. clavatus, Gryphæa Macculloch, Terebratula numismalis, Pinna folium, Pholadomya ambigua.*

[1] 'Quart. Jour. Geol. Soc.,' vol. xxxvi, p. 115, 1875.

Horizons.	Petrology.	Palæontology.
Bucklandi-zone. *Semicostatus*, and Upper Bucklandi-beds.	Scunthorpe Ironstone beds, with 27 per cent. ore, and having a thickness of 27 feet.	*Arietites Bucklandi, A. Crossii, A. Conybeari, A. semicostatus, A. stellaris, Aegoceras Boucaultianum, Nautilus striatus, Belemnites acutus, Pleurotomaria Anglica, Cardinia gigantea, C. copides, C. crassissima, Lima antiquata, L. gigantea, L. Hettangiensis, Pecten texturatus, Gryphæa arcuata, Hippopodium ferri, Cucullæa ovum.*
Bucklandi-zone. Lower Bucklandi-beds.	Lower limestone and marl in Frodingham Railway cutting.	*A. Bucklandi, A. Conybeari, A. semicostatus, Nautilus striatus, Belemnites acutus, Cardinia Listeri, C. concinna, Pleurotomaria Anglica, Lima antiquata, Pecten textorius, Gryphæa arcuata, Lima gigantea, Pholadomya ambigua, Unicardium cardioides.*
Angulatum zone.	Lowest Lias, Trent Valley, 150 feet. Dark shales and clays.	*Aegoceras Liassicum, A. angulatum, Nautilus striatus, Cardinia Listeri, C. concinna, Astarte obliqua, Pholadomya prima, Cardita Heberti, Modiola nitidula, Unicardium cardioides, Avicula decussata.*
	Planorbis-beds and	Avicula contorta series absent.
Keuper.	Red Marls.	No fossils.

In Yorkshire the Bucklandi-beds are exposed along the coast of Redcar and Robin Hood's Bay. In both localities they are, however, at high flood-tide covered by the sea, so that they are at all times studied with difficulty. Redcar affords the most complete section, and this has been well worked out by Messrs. Tate and Blake in their able and exhaustive work on the Yorkshire Lias. The sections I have given of these beds in the midland and southern counties of England show that they are there composed of thick-bedded blue hydraulic-limestones interstratified with beds of clay, but in Yorkshire the whole forms a "great argillaceous series, consisting of shales with shelly tops and thin, earthy, and shelly limestones."[1] The Redcar rocks consist of two sets of scars or ledges, separated by a broad expanse of a level pavement of shale. The scars succeed each other at pretty regular intervals, have the general direction of east by north and west by south, and are formed by the indurated tops of the shales. The inequality of the hardness of the scars and shales makes the shore appear like a deep ploughed field at low-tide. Their thickness is estimated at 180 feet, and they admit of a threefold division based on the Petrology and Palæontology of each series. Taking them in ascending order from the Angulatum-beds we have following series—

[1] 'Yorkshire Lias,' p. 54.

Horizon.	Petrology.	Palæontology.
Lower Series.	Black, crumbling shales, covered by thin, earthy, shelly limestones, 19 feet thick.	*Arietites Conybeari, Eucyclus elegans, Rissoa nana, Turbo philemon, Discohelix Oppeli, D. striata, Tancredia ovata, Plicatula liasina, Rhyn. plicatissima, Montlivaltia Haimei, Galeolaria socialis.*
Middle Series.	Soft blue shales, with rows of small limestone nodules in the upper part, friable shales, with shelly bands, thickness 93 feet.	*Arietites bisulcatus, Aegoceras Charmassei, Cryptænia solarioides, Turbo solarium, Cerithium gratum, Turritella Dunkeri, Lima gigantea, Unicardium cardioides, Cardinia crassiuscula, C. concinna, C. Listeri, Hippopodium ponderosum, Gryphæa arcuata, Lucina limbata, Pecten textorius, Montlivaltia Guettardi.*
Upper Series.	Earthy limestones, and calcareous shales, with agillaceous beds, thickness about 66 feet.	*Arietites Turneri, A. semicostatus, A. Sauzeanus, Belemnites acutus, B. infundibulum, Cardinia Listeri, Gryphæa arcuata, Lima gigantea, Pecten Thiollieri, Monotis inæquivalvis, Spiriferina Walcotii, Acrodus nobilis.*

Palæontology of the Bucklandi Zone.

Reptilia.

Ichthyosaurus communis, *Conybeare.*
— intermedius, *Conyb.*
Ichthyosaurus platyodon, *Conyb.*
— tenuirostris, *Conyb.*

Pisces.

Ichthyodorulites of Hybodus reticulatus, *Agass.*, and teeth of Acrodus nobilis, *Agass.*

Cephalopoda.

Arietites Bucklandi, *Sow.*
— bisulcatus, *Brug.*
— Conybeari, *Sow.*
— Sauzeanus, *d'Orb.*
— semicostatus, *Young & Bird.*
— Brooki, *Sow.*
— Scipionianus, *d'Orb.*
— rotiformis, *Sow.*
Aegoceras Charmassei, *d'Orb.*
Amaltheus Greenoughi, *Sow.*
Nautilus striatus, *Sow.*
Belemnites acutus, *Mill.*
— pencillatus, *Sow.*
— calcar, *Phil.*
— infundibulum, *Phil.*

Gasteropoda.

Pleurotomaria similis, *Sow.*
— Hennocqui, *Terq.*
— concava, *Mart.*
— tectaria, *Tate.*
Cryptænia solarioides, *Sow.*
— rotellæformis, *Dunk.*
Actæonina, fragilis, *Dunk.*
— sinemuriensis, *Mart.*
Turbo solarium, *Piett.*
Turbo philemon, *d'Orb.*
— reticulatus, *Moore.*
— Wilsoni, *Tate.*
Rissoa nana *Mart.*
Phasianella Morencyana, *Piette.*
Pitonellus sordidus, *Tate.*
Eucyclus elegans, *Münst.*
— selectus, *Chap. & Dewalq.*
Trochus Redcarensis, *Tate.*

Chimnitzia Collenoti, *Terq. & Piet.*
— unicingulata, *Terq.*
Cerithium gratum, *Terq.*
— Semele, *d'Orb.*
Turritella Zenkeni, *Dunk.*
Turritella regularis, *Terq. & Piet.*
— Dunkeri, *Terq.*
Discohelix Oppeli, *Mart.*
— striata, *Piette.*
Natica purpuroidea, *Tate.*

LAMELLIBRANCHIATA.

Ostrea semiplicata, *Münst.*
Pecten calvus, *Goldf.*
— textorius, *Scholth.*
— Thiollieri, *Mart.*
— punctatissimus, *Quenst.*
— lunularis, *Roemer.*
— Lohbergensis, *Emmerich.*
Lima Hettangiensis, *Terq.*
— gigantea, *Sow.*
— succincta, *Schloth.*
— pectinoides, *Sow.*
Limea Blakeana, *Tate.*
Monotis papyria, *Quenst.*
— inæquivalvis, *Sow.*
Gervillia Hagenovii, *Dunk.*
Perna infraliassica, *Quenst.*
Pinna Hartmanni, *Ziet.*
Inoceramus pinnæformis, *Dunk.*
Macrodon pullus, *Terq*
— naviculus, *Terq. & Piet.*
— Hettangiensis, *Terq.*
Leda Galathea, *d'Orb.*
— Renevieri, *Opp.*
— texturata, *Terq. & Piet.*
— subovalis, *Goldf.*
Nucula navis, *Piette.*
Modiola Hillana, *Sow.*
— lævis, *Sow.*
— bifasciata, *Tate.*
Protocardia Philippiana, *Dunk.*
Cardita Heberti, *Terq.*
Cardinia crassiuscula, *Sow.*
— concinna, *Sow.*
— Listeri, *Sow.*
Astarte obsoleta, *Dunk.*
— cingulata, *Terq.*
Tancredia ovata, *Chap. & Dewalq.*
— apicistria, *Rolle.*
Lucina limbata, *Terq. & Piet.*
Hippopodium ponderosum, *Sow.*
Myoconcha, psilonoti, *Quenst.*
Unicardium cardioides, *Phil.*
Gresslya Galathea, *Agass.*
Pleuromya liasina, *Schlüb.*
— crassa, *Agass.*
— Dunkeri, *Terq.*
Pholadomya glabra, *Agass.*
Homomya ventricosa, *Agass.*
Goniomya heteropleura, *Agass.*

BRACHIOPODA.

Spiriferina Walcotti, *Sow.*
Rhynchonella plicatissima, *Quenst.*
Discina Holdeni, *Tate.*

ANNELIDA.

Ditrypa globiceps, *Quenst.*
— capitata, *Phil.*
— quinquesulcata, *Münst.*
Serpula limax, *Goldf.*
— deflexa, *Phil.*
Galeolaria socialis, *Goldf.*

ECHINODERMATA.

Ophiura, *sp.*
Cidaris Edwardsii, *Wright.*
Himipedina Tomesii, *Wr.*
Pentacrinus basaltiformis, *Mill.*
— tuberculatus, *Mill.*
Holothuria spines?

ANTHOZOA.

Septastræa Murchisonæ, *Wr.*
Montlivaltia Haimei, *Chap.*
Montlivaltia Guettardi, *Blainv.*

Foreign Correlations.—Leopold von Buch[1] long ago remarked that "the Ammonites

[1] 'Die Ammoniten,' Akademie der Wissenschaften, Phys. Abhandl., p. 142, 1830.

of the Family Arietes are in general found together in great numbers; whole strata are sometimes composed of them, and they often grow to a very large size, from one to two feet in diameter. They are exclusively and only special to the Lias formation, and particularly in the lower beds thereof, where many different species are found. It is still remarkable that this group stands wholly isolated from all the others," and is well represented by *Arietites Bucklandi, Conybeari, rotiformis, stellaris, semicostatus.* In North Germany the Arietenschichten are well developed, and very rich in organic remains, as at Orsleben and near Harzburg, where the Bisulcatus-beds are worked for ironstone. At Sölenhai, near Liebenburg, and Falkenhagen, near Rischenau, the hydraulic limestone marls are found with *Arietites bisulcatus* and *Gryphæa arcuata* in great numbers.

In South Germany, in Württemberg, the Bucklandi-beds are developed near Stuttgart, where they repose on the Angulatum-beds, which are worked at Vaihingen for hydraulic limestone; in these Pflastersteine are found large specimens of *A. angulatum.* For one of these fossils, thirteen inches in diameter, I am indebted to my friend Professor Fraas. The twenty feet of Angulaten-Schichten are overlain by a thin seam of yellow clay, on which rests hard, dark-coloured limestone containing *Arietites Bucklandi, Conybeari, bisulcatus, obliquicostatus, Gryphæa arcuata,* and numerous other Mollusca, so that the rock is completely composed, as in several specimens before me, of shelly organic remains. The Bucklandi-beds are only about three feet thick, but very fossiliferous, and the Museums of Stuttgart and Tübingen contain extensive suites of fossils from these beds. In Baden the Lower Lias is found at Malsch and Oestringen, in the Langenbrück Jura, where the Planorbis-beds are overlain by the thick, hard, blue limestone of the Bucklandi-beds, the Angulatum series being here almost absent. *Arietites Bucklandi, A. spiratissimus, A. Turneri, Gryphæa arcuata, Lima Hermanni, L. gigantea, L. punctata, Pecten textorius, Pentacrinus tuberculatus,* Mill., and *Spirifer tumidus,* are the leading fossils here.

In the Breisgau Jura the Lower Lias is represented by the Bucklandi-beds, where the same species are found as at Malsch.

In the Swabian Jura at Küssaburg the black bituminous limestone charged with pyrites are overlain by bluish-grey thick limestone, extremely rich in organic remains. *Aegoceras angulatum, Arietites Bucklandi, Conybeari, Sauzeanus, Turneri, Kridion, raricostatus, Nautilus striatus, Pleurotomaria similis, Cardinia concinna, C. crassiuscula, Lima gigantea, L. Hermanni, Gryphæa arcuata, Pecten textorius, Spiriferina Walcotii, Pentacrinus tuberculatus,* Mill., are the fossils in these beds.

F. Ritter von Hauer, in his classical monograph "Ueber die Cephalopoden aus dem Lias der nordöstlichen Alpen,"[1] has given beautiful figures and most accurate descriptions of some of the most characteristic species of Ammonites from the Bucklandi-beds of the Eastern Alps, where these shells lie in a red-coloured limestone; we here find *Ar. rotiformis, A. Conybeari, A. bisulcatus, A. spiratissimus,* and *A. tardicrescens,* var. of *Conybeari, A. Kridion, A. stellaris, A. liassicus, A. hungaricus, A. Nodotianus, A. multicostatus.* All of these are well recognised forms of Bucklandi-zone.

[1] Denk. Kaiser, 'Akademie der Wissenschaft,' Wien, 1856.

In Luxembourg the Lower Lias is well developed, and the Bucklandi-beds represented by the upper portion of the Grès de Luxembourg. This formation has received different names by different authors; it is the "Calcaire sableux" of Boblaye, the "grès de Luxembourg" of Omalius, the "Steininger" of Dumont, the "Calcaire sableux" of Sauvage and Buvignier, the "Lias *a*" of Quenstedt, the "unterer lias Sandstein" of Roemer, the "Quadersandstein" (pars) of some German authors, and the "Grès liasique" of Terquem, with the Grès d'Hettange. In France, in Department of the Moselle, the Bisulcatus or Bucklandi-beds have been diligently studied by MM. Terquem and Piette, and the fruit of their labours is given in detail in their able work quoted already, in which the following species of Cephalopoda are catalogued from the Bisulcatus-beds: —*Arietites bisulcatus, A. Kridion, A. Conybeari, A. obtusus, A. Birchii, A. lacunatus, A. Boucaultianus, A. Laigneletii, A. centaurus, A. caprotinus, A. Hagenovi, A. raricostatus, A. lævigatus, A. sinemuriensis, Nautilus striatus, N. Schlumbergeri, Belemnites acutus.* Besides these there are 60 species of Gasteropoda, 106 species of Lamellibranchiata, 11 species of Brachiopoda, 8 species of Annelida, 6 species of Polyzoa, 12 species of Echinodermata, 3 species of Crustacea, 15 species of Anthozoa, 20 species of Foraminifera, and 3 species of Plants. Of this total 177 are found in lower zones, 57 are special to the Bisulcatus-beds, and 140 pass into the upper stages of life.

In the Côte d'Or M. Collenot, in his 'Description Géologique de l'Auxois,' has given a section of the Lower Lias, which shows the sequence of the beds near Semur.

The upper series represent the zone of *A. Birchii.*
The middle do. do. *A. Bucklandi.*
The lower do. do. *A. Scipionianus.*

The last rests upon the Angulatum-beds or the "Foie de Veau," and the following Palæontological list has been made with great care from the beds. I had the privilege, through the courtesy of MM. Collenot and Bréon, of examining all the species obtained therefrom, and contained in the Semur Museum.[1]

List of the Fossils of the Bucklandi-beds in the Côte d'Or, France.

Cephalopoda.

Arietites Scipionianus, *d'Orb.*
— Hehli, *Reynès.*
— viticola, *Dumort.*
— Rouvillei, *Reynès.*
— Schlombachi, *Reynès.*
— Charmassei, *d'Orb.*
— Delmasi, *Reynès.*
— Scylla, *Reynès.*
— circumdatus, *Mart.*
— Collenoti, *Reynès.*
— rotiformis, *Sow.*
— rotator, *Reynès.*
Arietites coronarius, *Quenst.*
— obesus, *Reynès.*
— bisulcatus, *Brug.*
— Vercingetorix, *Reynès.*
— Bucklandi, *Sow.*
— Sinemuriensis, *d'Orb.*
— striarius, *Quenst.*
— mandubius, *Reynès.*
— Deffneri, *Opp.*
— d'all'Eræ, *Reynès.*
— Terquemi, *Reynès.*
— Petri, *Reynès.*

[1] 'Description Géologique de l'Auxois,' p. 226; ibid., p. 235, 1873.

Arietites Conybeari, *Serv.*
— Conybearoides, *Reynès.*
— Aussoniensis, *Reynès.*
— Gmuendensis, *Opp.*
— compressarius, *Quenst.*
— Gaudryi, *Reynès.*
— Sauzeanus, *d'Orb.*
— subtaurus, *Reynès.*
— geometricus, *Opp.*
— falcarius, *Quenst.*
— ceratoides, *Quenst.*
— Birchii, *Sow.*
— obtusus, *Sow.*
— stellaris, *Sow.*

Arietites Æduensis, *d'Orb.*
— Breoni, *Reynès.*
— raricostatus, *Ziet.*
— rarisulcatus, *Quenst.*
Amaltheus oxynotus, *Quenst.*
— Lotharingus, *Reynès.*
Aegoceras Boucaultianum, *d'Orb.*
Amaltheus Guibalianus, *d'Orb.*
Arietites Nodotianus, *d'Orb.*
— debilitatus, *Reynès.*
— Bochardi, *Reynès.*
— Brookii, *Sow.*
— Landrioti, *d'Orb.*,
and others.

Gasteropoda.

Littorina clathrata, *Desh.*
Bulla Flouesti, *Deslong.*
Turritella Dunkeri, *Terq.*
Phasianella Morencyana, *Piet.*
Turbo decoratus, *Mart.*
— philemon, *d'Orb.*
Cerithium verrucosum, *Terq.*
— Semele, *d'Orb.*

Pleurotomaria Martiniana, *d'Orb.*
— Hettangiensis, *Terq.*
— Mosellana, *Terq.*
— Vanderbachii, *Terq.*
— Marcousana, *d'Orb.*
— gigas, *Deslong.*
Helcion, sp.

Lamellibranchiata.

Pleuromya, sp.
Pholadomya Voltzii, *Agass.*
— ventricosa, *d'Orb.*
— rhombifera, *Agass.*
— Idea, *d'Orb.*
Goniomya Sinemuriensis, *d'Orb.*
Tancredia, 4 species.
Isodonta Engelhardi, *Terq.*
Panopæa striatula, *d'Orb.*
— liasina, *d'Orb.*
Thracia, sp.
Lyonsa, sp.
Arcomya, sp.
Astarte, 2 sp.
Cardinia Listeri, *Sow.*
— hybrida, *Stuchb.*
— Eveni, *Terq.*
— angustata, *Agass.*
— lanceolata, *Stuchb.*
— copides, *Terq.*
— insignis, *Mart.*
Mactromya, sp.

Nucula, sp.
Psammobia, sp.
Pinna Hartmanni, *Ziet.*
— folium, *Phil.*
Avicula Sideloci, *Mart.*
— sinemuriensis, *d'Orb.*
Mytilus Guexii, *d'Orb.*
Inoceramus, sp.
Lima antiquata, *Sow.*
— gigantea, *Sow.*
— Erosne, *d'Orb.*
— punctata, *Sow.*
— Hettangiensis, *Terq.*
Pecten Helbii, *d'Orb.*
— dispar, *Terq.*
— textorius, *Schloth.*
Hinnites liasinus, *Terq.*
Ostrea multicostata, *Munst.*
Gryphæa arcuata, *Lamk.*
— Maccullochii, *Sow.*
— obliquata, *Sow.*

BRACHIOPODA.

Spiriferina pinguis, *Ziet.*
— Walcotii, *Sow.*
Rhynchonella variabilis, *d'Orb.*
Terebratula perforata, *Piet.*
Terebratula cor., *Lamk.*
— punctata, *Sow.*
— indentata, *von Buch.*

ECHINODERMATA, POLYZOA, ANTHOZOA.

Pentacrinus tuberculatus, *Mill.*
Neuropora mamillata, *de From.*
Cidaris, sp.
Montlivaltia Sinemuriensis, *de From.*

FORAMINIFERA, 15 species.

4. The Zone of Arietites Turneri.

Synonyms. — "Hauptpentacrinitenbank des untern Lias," Quenstedt, 'Flozgeb.' p. 152, 1843. "Lumachelle de *Pentacrinites basaltiformis*," Marcou, 'Jura salinois,' p. 47, 1846. "Die Schichten des *Pentacrinus tuberculatus*" Oppel, 'Juraformation,' p. 44, 1856. "Tuberculatus-bed," Wright, 'Quart. Journ. Geol. Soc.,' vol xiv, p. 25, 1858. "Marne de Strassen," Dewalque et Chapuis, 'Fossiles de Luxembourg,' 1853. "Zone of *Ammonites Turneri*," Wright, 'Quart. Journ. Geol. Soc.,' vol. xvi, p. 403, 1860.

This subdivision of the Lower Lias forms a well-marked zone of life. The beds consist of light-coloured argillaceous limestone, of hard greyish limestone, or of deep-blue shelly, indurated shale, interstratified with beds of dark-coloured clay. Many of the slabs of limestone are covered with shells and portions of the stem and side arms of *Pentacrinus tuberculatus,* Mill. From one of these slabs, collected at Frethern or Purton, in Gloucestershire, Miller's original specimen of this Crinoid was obtained.

Gloucestershire and Warwickshire.—The *Turneri* zone was exposed at Bredon, in the deep cuttings of the Bristol and Birmingham Railway, from whence my type specimen (Pl. XII) was obtained. In the Vale of Gloucester portions of these beds are sometimes laid open in making drains, as at Badgeworth and Hardwick; and many fine slabs are occasionally procured from the Severn section at Purton. I know of no locality in Gloucestershire, where the entire series is shown. My late friend, Dr. Oppel,[1] referred the Saurian beds of Brockeridge Common to this zone. This I have shown, at p. 17, to be an error, as the Brockeridge Common-beds form a portion of the zone of *Aegoceras planorbis,* whereas the Fish and Saurian beds at Lyme Regis, with which he identified the Brockeridge-beds, certainly belong to the zone of *Arietites Turneri,* as the following section indicates. In Warwickshire the *Turneri* beds constitute the base of what is called in that county the "Cardinia-series;" in these are included all the strata of the Lower Lias between the *Turneri* and *raricostatum* beds, characterised by different forms of the genus *Cardinia.*

[1] 'Die Juraformation,' p. 49, 1856.

Dorsetshire.—At Lyme Regis the *Bucklandi* series is overlain by thick beds of clay and slaty marls containing many Enaliosaurian skeletons, with numerous Fishes, in fine preservation; these strata are known to local collectors as the Fish- and Saurian-beds. The magnificent specimen of *Ichthyosaurus platyodon*, Conyb., now in the British Museum, came from this clay, as proved by the impressions of *Arietites semicostatus* seen on the matrix. This thick clay-bed is underlain by a thin band of greyish-limestone, in which *Ar. Turneri* is found. The following section at Lyme Regis shows the sequence of the *Turneri* beds at that locality in a descending order.

Section of the Zone of Arietites Turneri *at Lyme Regis.*

	No.	Lithology.	Thickness.	Organic Remains.
			ft. in.	
Beds with *Arietites Turneri.*	1	Thick limestone, "Broad Ledge"	3 6	*Ichthyosaurus platyodon*, Conyb., *I. communis*, Conyb., *Arietites semicostatus*, *Ar. Turneri*, Sow., and Fishes.
	2	Black shales, with bands of brown clay. "Saurian- and Fish-bed"	18 0	
	3	Greyish, hard, shelly limestone	0 4	*Arietites Turneri*, Sow., and *Ar. semicostatus*, Young and Bird.
	4	Dark shales, with indurated bands of imperfect limestone	3 0	
		Greyish limestone.....		*Lima gigantea*, Sow., *L. antiquata*, Sow., and *Rhynchonella variabilis*, Schloth.

Beds with *Arietites Bucklandi* and *Lima gigantea.* (See p. 38.)

Fossils of the Zone of Arietites Turneri.[1]

Ichthyosaurus platyodon, *Conyb.* (British Museum).
— intermedius, *Conyb.* (Warwick Museum).
— communis, *Conyb.* (British Museum).
Arietites Turneri, *Sow.*
— semicostatus, *Young & Bird.*
— Bonnardi, *d'Orb.*
Turbo solarium, *Piette.*
Lima punctata, *Sow.*
— gigantea, *Sow.*
— pectinoides, *Sow.*
Cardinia ovalis, *Stutch.*
Ostrea Goldfussii, *Bronn.*
Avicula inæquivalvis, *Sow.*
Pecten textorius, *Schloth.*
— glaber, *Hehl.*
Astarte obsoleta, *Dunk.*
Crenatula, nov. sp.
Plicatula spinosa, *Sow.*
Gervillia Hagenovii, *Dunk.*
Gryphæa arcuata, *Lamk.*
Cidaris Edwardsii, *Wr.*
Pseudodiadema spines.
Pentacrinus tuberculatus, *Miller.*

[1] I have omitted the Lias Fishes found at Lyme Regis, as there is some doubt about the beds from which the different species were collected; a large majority of them, however, I believe, were obtained from this zone of life.

PLATE I.

Zone of Arietites Bucklandi.

Fig. 1. Arietites Bucklandi, *Sowerby*. Lateral view. Half natural size. From the Ironstone beds at Scunthorpe, north-west Lincolnshire. My collection.

2. Front view of the same Ammonite.

3. Enlarged figure of the foliations of the septa.

4. Arietites semicostatus, *Young and Bird.* = Arietites geometricus, *Oppel.* Lateral view. Natural size. My collection.

5. View of the siphonal area, showing the compressed sides and angular keel.

6. Enlarged figure of the foliations of *A. semicostatus.*

7. Young shell, smooth like *A. planorbis;* being the four inner whorls of A. semicostatus. My collection.

8. Young shell, in which ribs are developed in early life. My collection.

Fig. 1

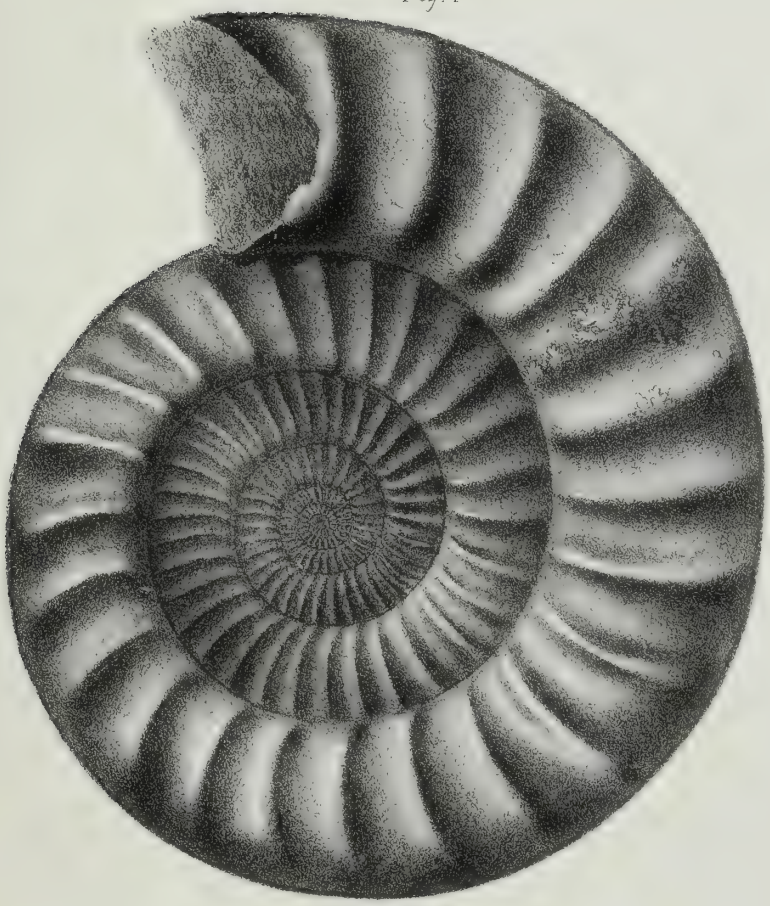


Fig. 2

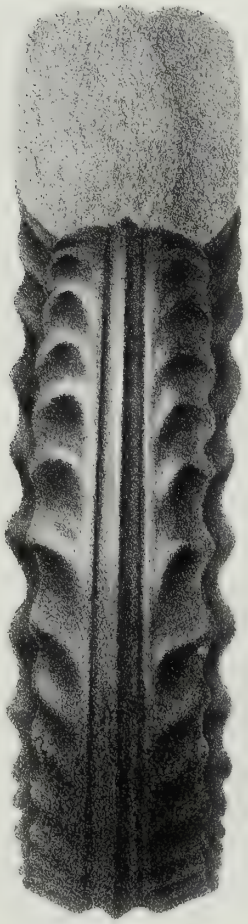


Fig. 3

Fig. 4

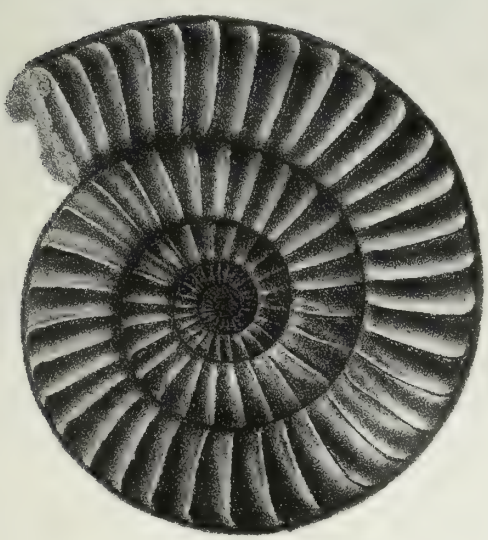


Fig. 5

Fig. 6

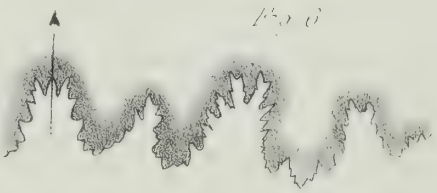


Fig. 7

Fig. 8

A.Gawan lith

Hanhart imp

PLATE II.

Zone of Arietites Bucklandi.

Fig. 1. Arietites Conybeari, *Sowerby*. Lateral view. Half natural size. My collection.

2. Front view of the same Ammonite, showing siphonal area and bisulcations, in same proportion.

3. Foliations of the septa magnified.

This fine type shell was obtained from the Great Western Railway cutting at Saltford near Bath when the line was making. A magnificent specimen of this species, nearly as large as a small carriage wheel, from the same locality, collected by me, is now in the British Museum.

Fig 1

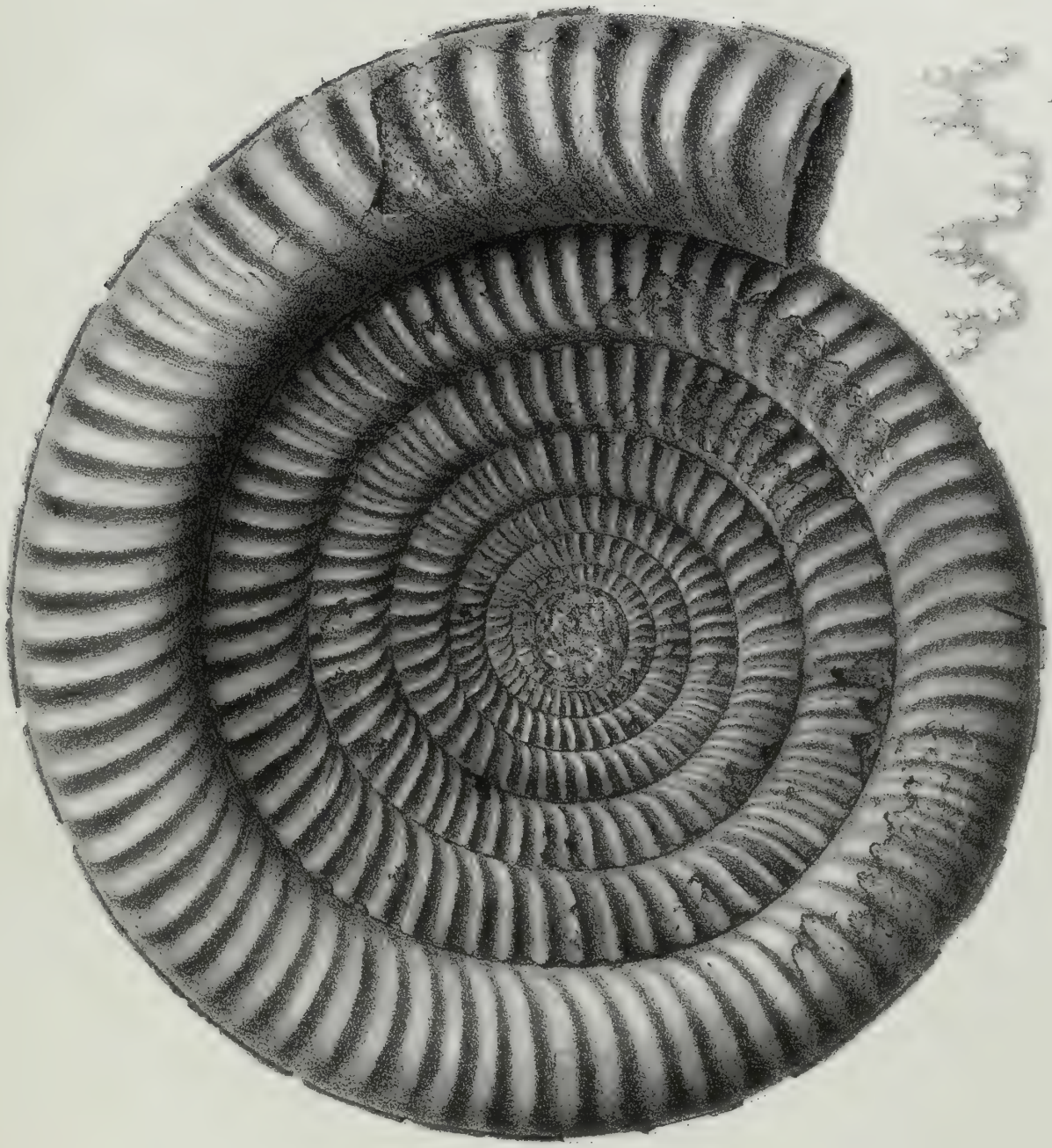
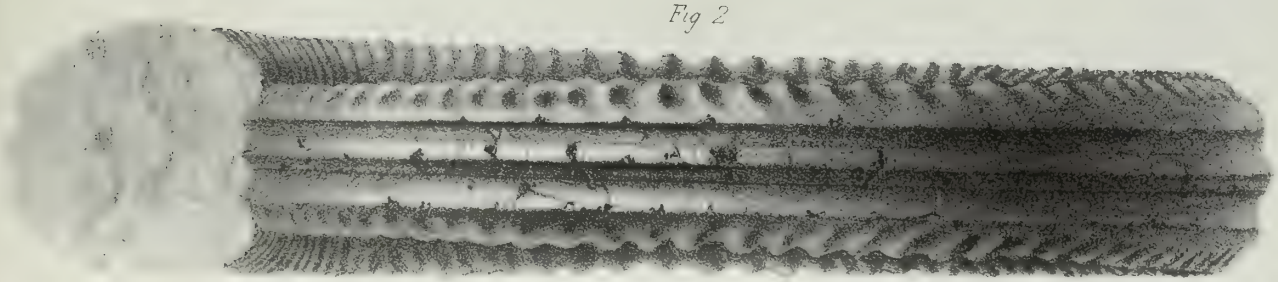


Fig 3

Fig 2



A Sowerby

Armitage imp

PLATE III.

Zone of Arietites Bucklandi.

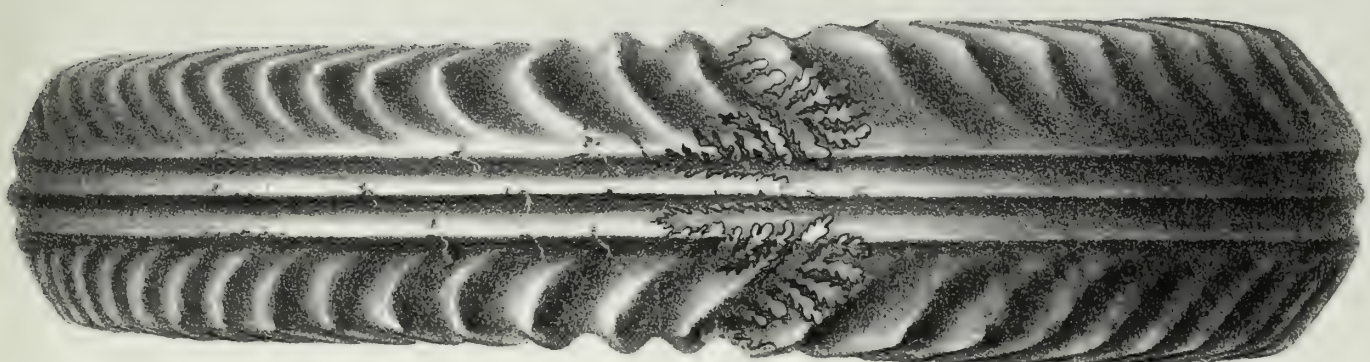
Fig. 1. Arietites bisulcatus, *Bruguière* = Arietites multicostatus, *Sowerby*. Lateral view of a fine typical specimen, showing the foliations of the superior and inferior lateral lobes. Collected at Frethern-on-Severn, Gloucestershire, by John Jones, Esq., and now in the Museum of the School of Art and Science, Gloucester.

2. View of the siphonal area of the same Ammonite, showing the foliations of the siphonal lobes *in sitú*.

3. An accurate outline of the foliations of the septa, showing the siphonal, superior lateral, inferior lateral, and auxiliary lobes.

Fig 1

Fig 2



A.Gawan lith.

Hanhart imp.

PLATE IV.

Zone of Arietites Bucklandi.

Fig. 1. Arietites bisulcatus, *Bruguière* = multicostatus, *Sowerby*. Lateral view, natural size, of a typical specimen from the Lower Lias, near Berkeley. My collection.

2. Front view of the same, showing the position of the siphuncle.

3. View of the siphonal area of the same, showing the bisulcations on each side of the keel, the tubercles on the ribs, and their angular curvature forwards on the margin of the siphonal area.

4. Accurate outline of the foliations well seen in this specimen.

Fig 1

Fig 2

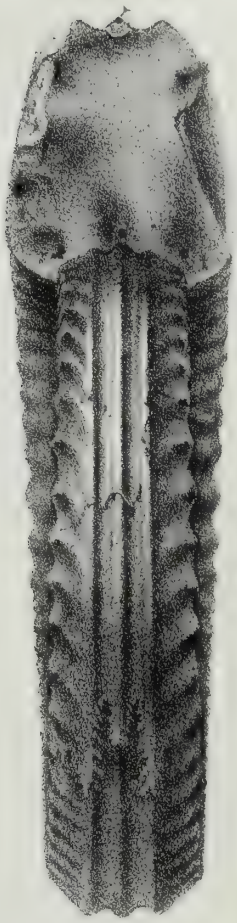


Fig. 4

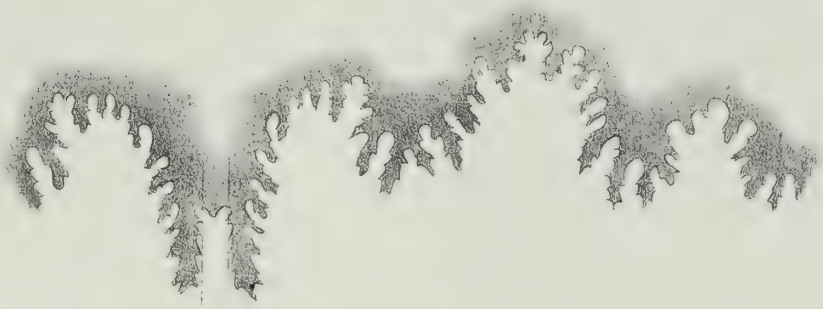
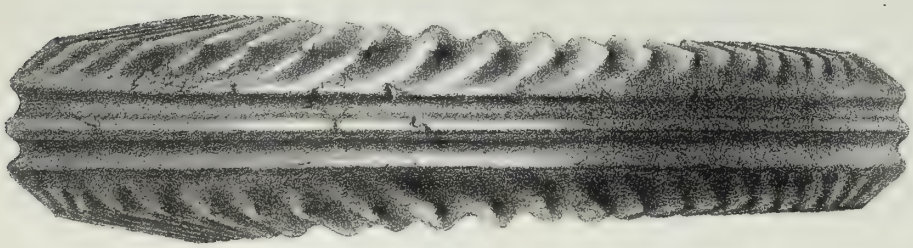


Fig. 3.



A.Gawan lith

Hanhart imp

PLATE V.

Zone of Arietites Bucklandi.

Fig. 1. Arietites rotiformis, *Sowerby*. Lateral view, natural size, of the original type specimen figured by the late Mr. James De C. Sowerby in the 'Mineral Conchology' in 1825, from an example collected near Yeovil, and now in the British Museum. This fossil has a very rugged surface, owing to the shell having become decomposed in patches on the ribs and other parts.

2. View of the siphonal area of the same specimen, with the siphonal foliations *in situ*. Natural size.

3. Front view of the same, showing tubercles, keel, and bisulcations. Natural size.

4. View of the siphonal area of a large example from Lyme Regis, showing the shell-structure, keel, bisulcations, and siphonal ribs. Natural size.

Fig 1.

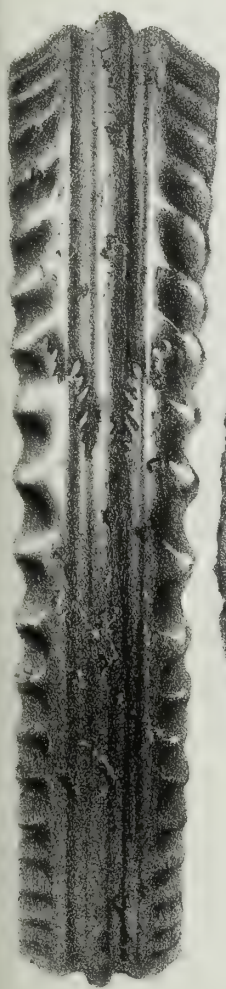


Fig 2.

Fig 3.

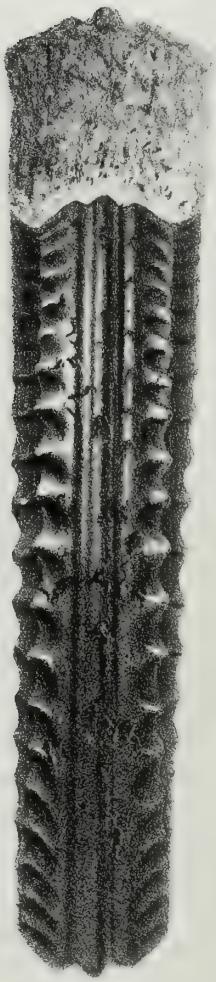
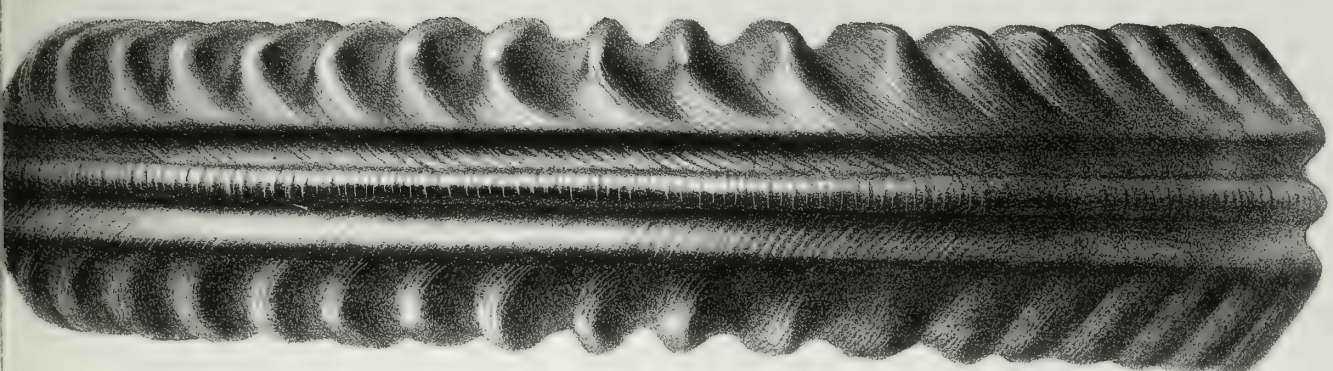


Fig 4



Gawan lith

Hanhart imp

PLATE VI.

Zone of Amaltheus oxynotus.

Fig. 1. Arietites denotatus, *Simpson*. Lateral view. Natural size. The finest specimen known; from the Leckenby Collection, Woodwardian Museum, Cambridge.

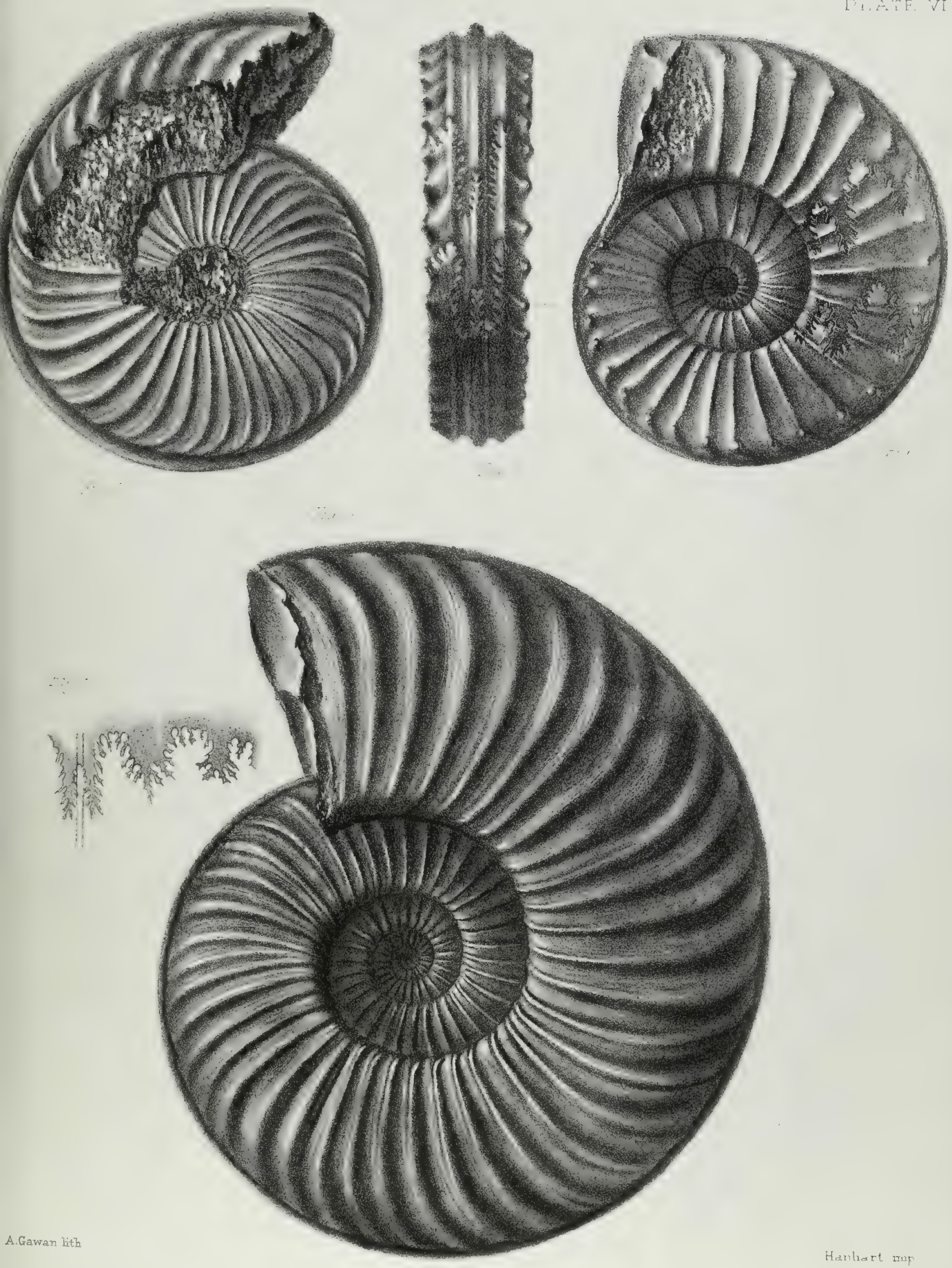
2. Arietites nodulosus, *Young and Bird* = Arietites obesulus, *Blake*. Lateral view of a small perfect specimen, magnified two diameters, collected from a brown sandy rock, Robin Hood's Bay. My collection.

3. View of the siphonal area of the same shell, showing the line of tubercles on the margin, with the oblique-forward directed ribs arising from the tubercular series. The outline of the foliations of the lateral lobes is well shown in Fig. 2, and the siphonal lobes are remarkable for their great elongation, and are seen in Fig. 3, where the superior lateral, inferior lateral, and auxiliary lobes are shown *in sitû*.

Zone of Arietites Bucklandi.

Fig. 4. Arietites Brooki, *Sowerby*. Lateral view, natural size, of a very beautiful Ammonite, with the shell-structure in fine preservation, and showing the lines of growth on its surface. My collection.

5. Accurate outline of the foliations of *Arietites Brooki* from another specimen, as none are visible in Fig. 4, in consequence of the presence of the shell all over the mould. My collection.



A.Gawan lith

Hanhart imp

PLATE VII.

Zone of Arietites Bucklandi.

Fig. 1. Arietites rotiformis, *Sowerby*. Lateral view of another specimen in the Sowerbyan Collection in the British Museum, entirely denuded of shell, and showing the mould forms of the ribs and tubercles. Natural size.

Zone of Arietites raricostatus.

Fig. 2. Arietites raricostatus, *Zieten*. Lateral view, with much of the shell preserved; from a fine specimen in the British Museum. Natural size. Locality unknown.

3. View of the siphonal area of the same shell, showing the keel and the disappearance of the ribs after they turn the border.
4. Front view of the same shell showing like characters. Natural size.
5. Form of the foliations in this species.
6. A smaller individual of the same species, in my collection, to show the size of the air-chambers and the distance the septa are from each other.

Fig. 1

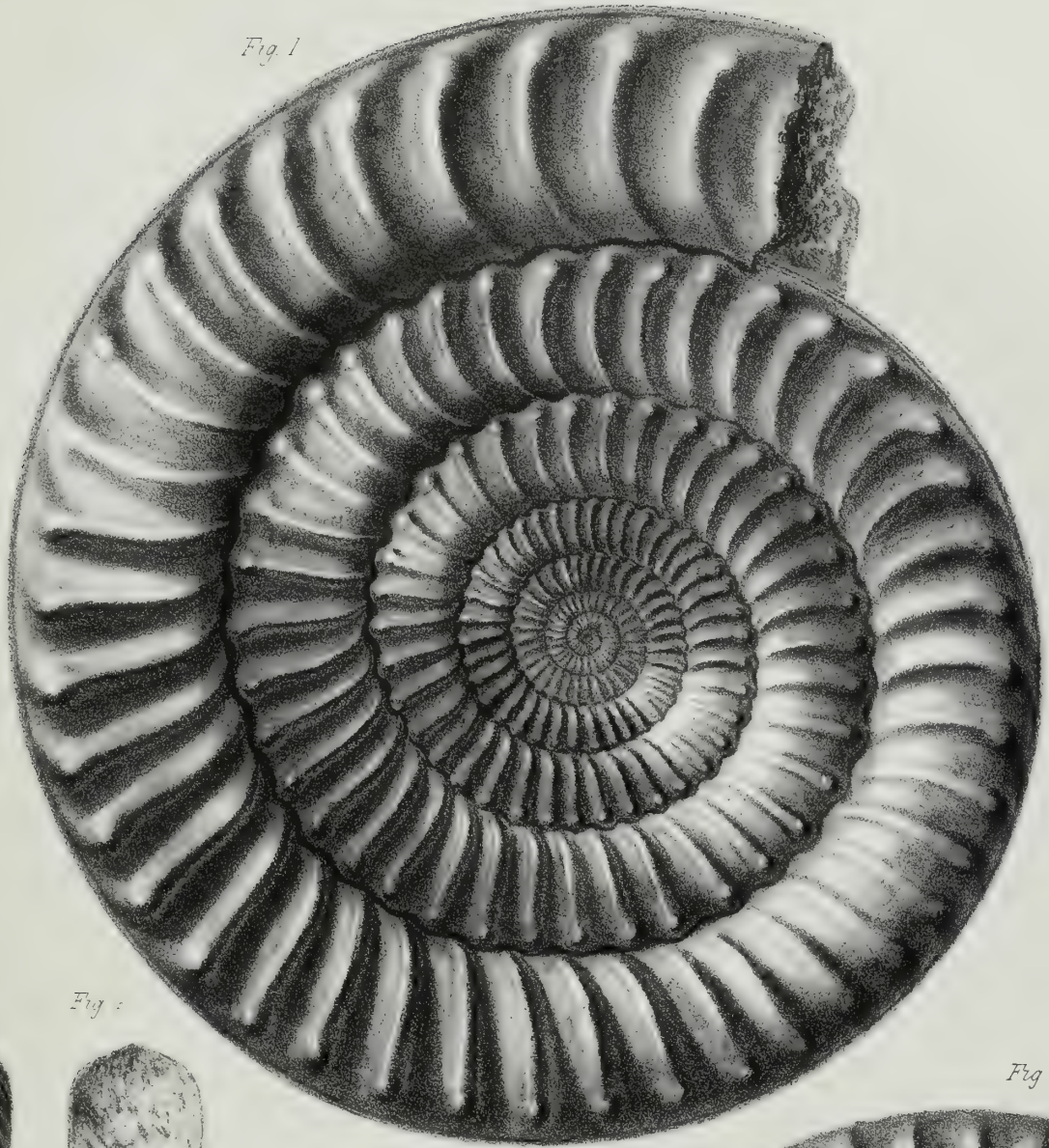


Fig. 3

Fig. 4

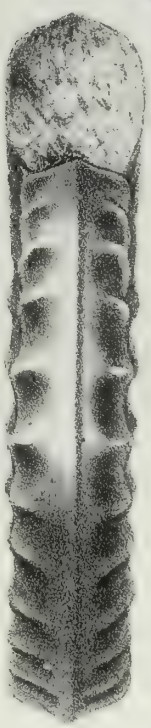


Fig 2

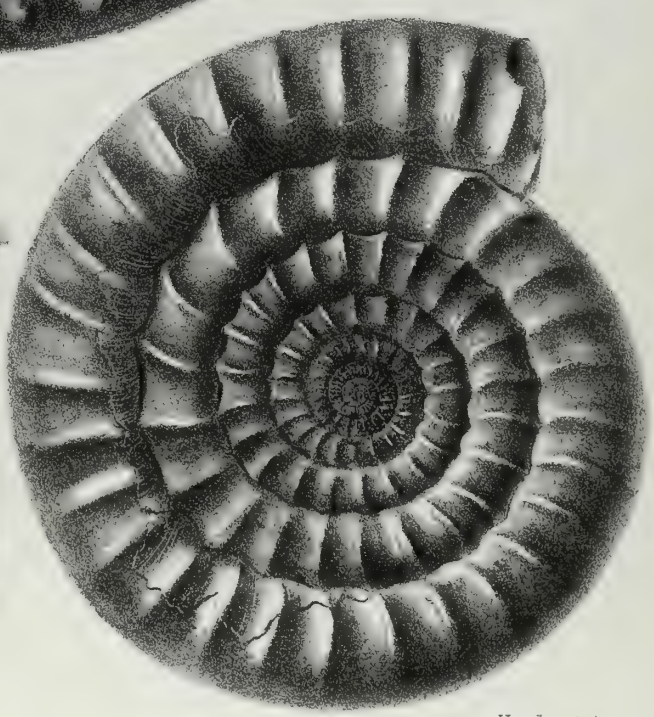
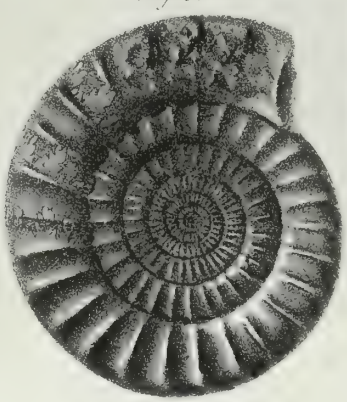


Fig 5

Fig 6.



A.Gawan lith

Hanhart imp

PLATE VIII.

Zone of Arietites Bucklandi.

Fig. 1. Arietites Sauzeanus, *d'Orbigny*. A large specimen, in my collection ; collected at Bredon, Midland Railway cutting, Gloucestershire. Lateral view, natural size, showing the rib-flexures and tubercles near the outer margin of the siphonal area. Most of the shell preserved.

2. Front view of the same fossil, showing lobes, keel, and tubercles.

3. Accurate outline of the foliations of the septa in this species.

4. Lateral view of a smaller shell, collected at Darlingscott, near Shipton-on-Stour, Worcestershire, showing the sharp ribs and tubercles. Natural size.

5. Lateral view of a small shell from Darlingscott, showing the sharpness of the mould. Natural size. The Darlingscott specimens were collected by my friend John Kershaw, Esq., Warwick, and kindly presented to me for this work.

6. View of the siphonal area of the same. The keel and ribs are more prominent in this specimen than usual on the siphonal area. Natural size.

Fig 2

Fig 1

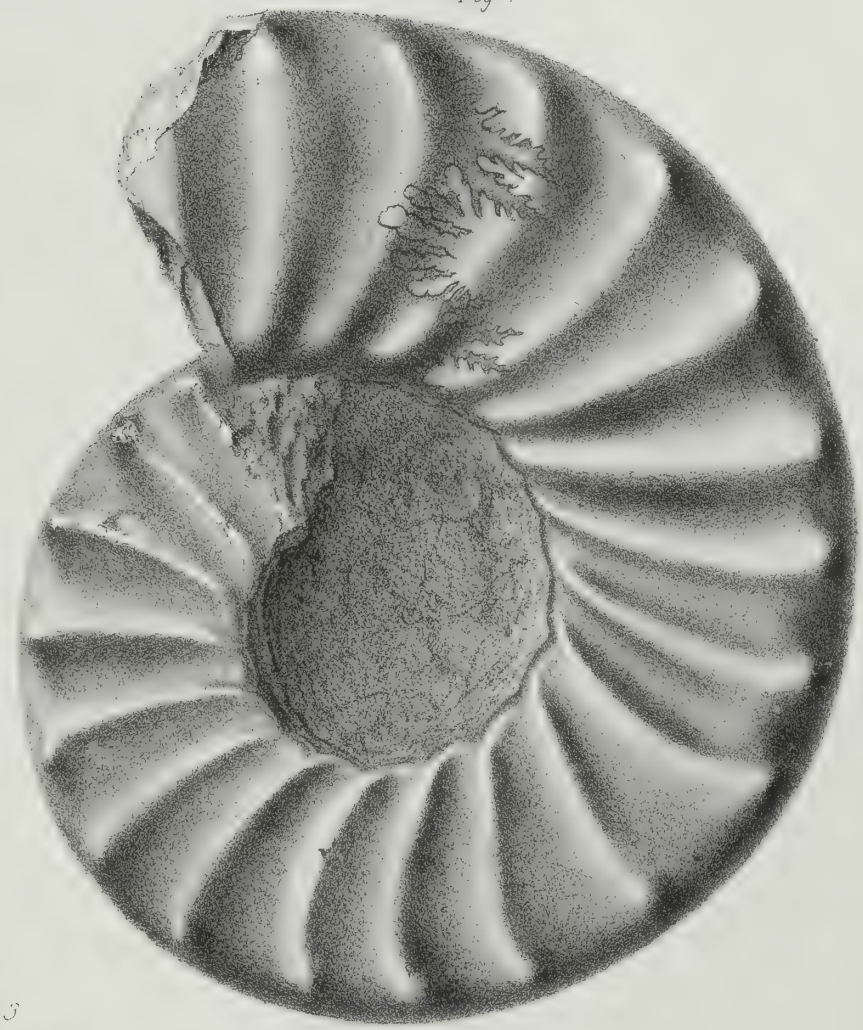


Fig 3

Fig 4

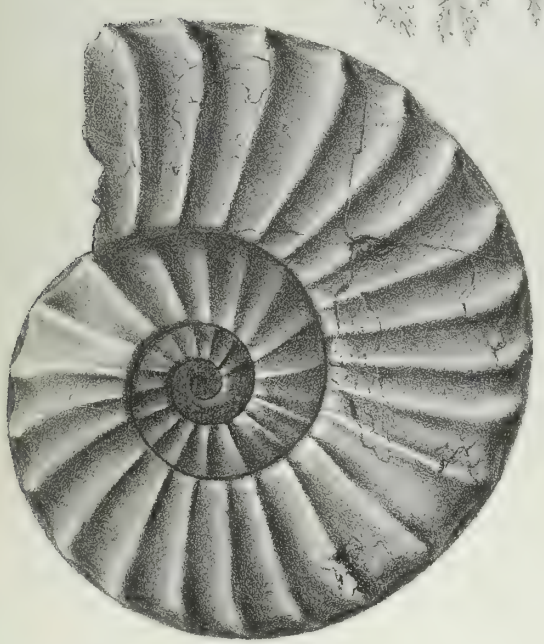


Fig 5

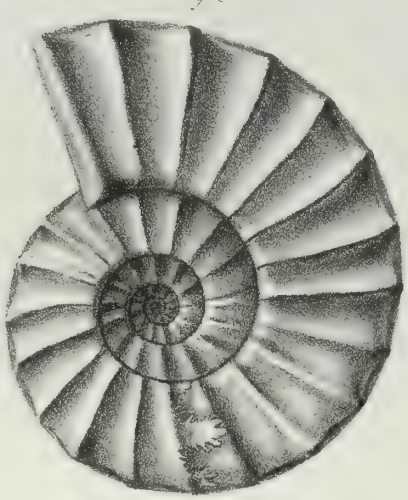


Fig 6

A.Gawan lith.

Hanhart imp.

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MONOGRAPH

OF THE

SIRENOID AND CROSSOPTERYGIAN

GANOIDS.

BY

L. C. MIALL,

PROFESSOR OF BIOLOGY IN THE YORKSHIRE COLLEGE, AND CURATOR TO THE LEEDS MUSEUM.

PAGES 1—32; PLATES I, IA, II—V.

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1878.

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MONOGRAPH

OF THE

SIRENOID AND CROSSOPTERYGIAN GANOIDS.

This treatise attempts to collect into one view the most important facts which have been ascertained respecting the organisation and classification of at least the more typical Ganoid fishes. To compare in their principal features similar forms of all geological periods is the author's object, and not the detailed investigation of a particular fauna. It will therefore be necessary to leave to the compilers of more special memoirs all structural details of little physiological or morphological value, while the present arrangement will be zoological and not stratigraphical.

The practice of the Palæontographical Society, no less than the local restriction of an author, requires that the British species should receive the chief attention. This limitation is not so damaging to the usefulness of a memoir on Ganoid fishes as might at first sight appear. British rocks have yielded a very considerable proportion of the genera hitherto defined, and nearly all the chief modifications of Ganoid structure can be fairly illustrated by British examples. It will be necessary to introduce genera wholly foreign at times; in particular, the recent Ganoids, none of which are strictly British, will require full consideration.

The known Ganoidei are already very numerous, and it would be unwise to count upon the time necessary for their complete revision. I have therefore definitely undertaken only two sections of the order, but it is my present intention to review, sooner or later, the remaining suborders.

Useful general principles relating to the distribution and derivation of animal types will, it is hoped, come to light in the progress of these studies, and this expectation is the chief motive for undertaking so lengthy and troublesome a work. The difficult inquiry, "What is a Ganoid?" may also receive elucidation. It would be proper to discuss this fundamental question at once, if the order were throughout its history so sharply defined as to render serious mistakes improbable. Unfortunately, this is not the

case. Difficulties of the most grave kind appear whenever it is attempted to frame a definition inclusive of all the fossil forms. Some of the best characters of recent Ganoids are founded upon perishable parts, such as the brain, heart, and intestine. Moreover, palæontology has already brought to light many intermediate and doubtful forms, which impair almost any precise general statement, while others are likely to occur as the rocks are more diligently searched. Under these circumstances a slow constructive method must be tried, and the desired definition will be attained, if at all, at the close and not at the outset of our investigations.

We are not, however, entirely in the dark as to what constitutes a Ganoid fish. The recent members of the order have come by extinction of connecting forms to constitute a somewhat isolated group, capable of definition. The construction of this definition is historically interesting, and in recapitulating the steps by which it was gradually framed we shall be led to explanations which would in any case form necessary prolegomena to a descriptive memoir of the Ganoid order.

The ichthyological method of Cuvier is well known, and need not be discussed at length. For our purpose it is only necessary to remark that the order Ganoidei was therein broken up into two widely separate sections. The Sturgeons and Polyodons went among the Chondropterygian or Cartilaginous Fishes; *Lepidosteus* and *Polypterus* ranked side by side with the Salmons and Herrings among the Malacopterygii Abdominales. Here, too, *Protopterus* was assigned a place when first included by Owen in the class Pisces. Had *Calamoichthys* been known to Cuvier it would have gone among the Eels as one of the Malacopterygii Apodes.

It was a step forward when Agassiz announced his views on the method of classifying fossil fishes. He rescued the Ganoid order as a whole, placing the cartilaginous Sturgeons side by side with the osseous *Polypterus* and *Lepidosteus*. But the grounds on which this was done were unsatisfactory. It is, perhaps, almost needless to describe the arrangement of Agassiz. In geological text-books it still holds a respected place, though banished from zoology. We have four groups based upon tegumentary organs—*ganoid*, with (usually) rhomboidal or polygonal scales covered with enamel; *placoid*, with shagreen or prickly tubercles; *ctenoid*, with membranous scales jagged on the hinder edge; *cycloid*, with rounded scales destitute of enamel.

This classification is simple and easy to apply. Modern naturalists are, however, unanimous that the application of any test of texture or form of scales would remove true Ganoids from the group and introduce alien genera having no real affinity with the order. *Amia*,[1] with its cycloid scales, the two species of *Polyodon*, with their nearly

[1] Mr. Bridge ('Journal of Anatomy,' vol. xi, p. 621, 1877) considers that on the whole the Teleostean affinities of *Amia* predominate. This conclusion is not consistent with the views here advocated, but it must not be dogmatically rejected. *Amia* has not yet found its place in any closely connected chain which includes typical Ganoids; and while one tenable definition would enable it to be claimed as a Ganoid, another would place it among the Physostomi. This systematic uncertainty, so

naked skin, would be set aside in spite of the Ganoid character of their heart, intestine, and optic nerves. *Balistes*, *Loricaria*, and a number of Plectognathous fishes would enter the order, entitled to do so solely by their osseous scutes. The zoologist cannot tolerate any principle of division which involves such separations and combinations as these.

Müller has pointed out how destitute of value is any classification of Teleostean fishes based upon scale characters. Well-defined and natural families contain both cycloid and ctenoid genera. Genera can be named with both cycloid and ctenoid species. *Atherina* (the Sand Smelt) and *Mugil* (the common Mullet) both belong to one family, the *Mugilidæ*, yet the first is cycloid and the second ctenoid. The families *Percidæ*, *Clupeidæ*, *Gobidæ*, and many others include both forms. Thus, the *Scombridæ*, ranked by Agassiz as cycloid, contain such genera as *Nomeus*, *Cubiceps*, and *Neptonemus*, which are truly cycloid, while *Platystethus* is ctenoid, and *Pelamys Sarda* both ctenoid and cycloid. In short, scale-characters tell us nothing unless the affinities of the fish in question are beforehand nearly determined.

In 1844 appeared the celebrated memoir of Müller, 'Ueber den Bau und die Grenzen der Ganoiden,'[1] a work which marks the era of sound general principles of definition and classification of Ganoid fishes. The author gives first a historical *résumé* of the work done by his predecessors in this field of inquiry, Rafinesque, De Blainville, Cuvier, and Agassiz. The views of the last only of these receive a full discussion, for he alone had recognised the ties which connect the Ganoids together. Briefly, but with irresistible weight of argument, Müller disposes of the arrangement based upon scale characters. He points out the many fatal anomalies which result from the definitions of orders according to Agassiz, and shatters all hope of establishing a natural history upon such easy distinctions. The essential peculiarities of the Ganoids are shown to lie, not in scales, fins, or tail, but in the heart, brain, and intestine.

The anatomical research of this essay gives it a permanent value which the labours of no mere systematist can confer. The structure of *Polypterus* and *Lepidosteus* in particular is given with a fulness and completeness which more recent investigation has hardly modified. In the reconstruction of the order certain of the Siluroids, Scleroderms, Gymnodonts, and Lophobranchs, admitted by Agassiz as armour-plated fishes, are removed entirely from the order Ganoidei. The remaining recent genera are enumerated by Müller thus: *Lepidosteus*, *Polypterus*, *Acipenser*, *Scaphirhynchus*, and *Polyodon*.

Since 1844 the list of genera has been modified as follows. The Ganoid structure of *Amia*, discovered by Vogt, is announced in a postscript to Müller's paper. *Calamoichthys*, first described in 1865, and *Ceratodus*, added to the list of living genera in 1870, were unknown to Müller. *Lepidosiren* and *Protopterus*, excluded by Müller, it is now

puzzling to the pure zoologist, is most interesting and suggestive to those who seek to infer biological principles from the results of zoology.

[1] 'Abhandlungen der Akademie der Wissenschaften zu Berlin,' 1844.

proposed to readmit. The conspicuous differences of their structure from that of the typical Ganoids have been bridged over by the discovery of *Ceratodus*, as will shortly appear. In other respects Müller's restricted order is coextensive with that of the modern ichthyologist, and the ordinal definition (with the exception of one character noted by Müller himself as provisional) stands unshaken.

That definition comprehends the following differentiæ of Ganoid fishes.

A Teleostean fish has a two-chambered heart from which ascends the cardiac aorta, dilated a little at its origin, not rhythmically contractile, and separated from the ventricle by a pair of opposite valves. In a Ganoid fish a far more complex structure appears. The dilated origin of the aorta is strengthened by numerous additional muscular fibres,[1] which almost entitle it to rank as a third chamber of the heart; it is, besides, rhythmically contractile. On slitting open this part of the aortic tube (the *bulbus arteriosus*) rows of valves appear, generally attached to the inner arterial wall transversely, but ranged in longitudinal rows. *Polypterus* has three principal vertical series, each including nine valves. Alternating with these are three incomplete series, each containing five to nine valves of less size. *Lepidosteus osseus* has from five to eight vertical rows, comprehending from forty to seventy valves[2] similar to each other and uniformly situated. *Amia* has five to six vertical series, with two valves in each; *Acipenser*, four or five vertical series of three or four valves in each; *Polyodon*, four vertical rows with three valves in each. The number, arrangement, and relative size of these valves is not quite uniform for the same species. The valves are generally connected together by delicate tendinous chords, each to the one above it in the same vertical row.

No such structure is known among Teleostean fishes. The Sharks (especially *Lamna cornubica*, the Porbeagle) have valves in the *bulbus arteriosus*, though less numerous and arranged in three vertical rows. Other *Plagiostomi* recede still further from the Ganoid type, though the *bulbus arteriosus* and some trace of the three series of valves are perhaps always to be found. *Lepidosiren* and *Protopterus* exhibit the *bulbus arteriosus* with two longitudinal valves. The two valves found at the ventricular end of the bulb in Teleostei are wanting in Ganoids and Plagiostomi alike. The presence of a contractile *bulbus arteriosus* furnished internally with valves is thus seen to be a valuable character separating the Ganoids from the Teleostei, Marsipobranchii (Lampreys), and Leptocardii (*Amphioxus*), though not distinguishing them from *Lepidosiren*, *Chimæra*, the Sharks or Rays.

A second differential character of Müller's restricted order Ganoidei is to be found in the optic nerves. In the Lampreys and Hags the optic nerve proceeds direct to its orbit from the *thalamus opticus* of the same side. In a Teleostean fish the nerves decussate, all the fibres from one side of the brain crossing over to the retina of the other side.

[1] In *Amia* these muscular fibres extend but a short distance up the bulb.

[2] I have found some of the rows in the bulbus arteriosus of *Lepidosteus* united together and to the wall of the cavity, so as to constitute a kind of longitudinal valve.

Higher vertebrata than fishes possess a still more complex arrangement (*chiasma*), a redistribution, at the point of decussation, of the fibres in their passage forward to the orbit. The physiological bearing of these differences of structure is not unimportant, but we are here concerned only with their systematic value. In no Ganoid fish are the optic nerves known to decussate. It may be that a chiasma is always present, but whether this be so or not, non-decussation of the optic nerves associates the Ganoids, Sharks, Rays, and *Chimæra*, and separates them from Teleostei.

Müller includes free gills and the presence of a gill-cover as a third distinctive feature of Ganoids. In *Chimæra*, Sharks, and Rays (hence termed *Elasmobranchii* by Bonaparte) the gills adhere to the outer wall of the gill-cavity, and are thus comparatively fixed, being attached at each end. Water enters the respiratory chamber by from five to seven lateral openings in the case of the Plagiostomi; by a single aperture (leading to four branchial clefts) in *Chimæra*. In the last genus a rudimentary cartilaginous gill-cover occurs. Teleostei have gills supported on branchial arches, but not attached to the sides of a gill-cavity. The outer wall of the respiratory chamber is formed of a movable *operculum* or gill-cover. Thus Ganoids, with their free gills and gill-cover, resemble the Teleostei, and recede from the Elasmobranchii, so far as their respiratory apparatus is concerned. *Ceratodus* has each of its gills attached externally to the wall of the gill-cavity.

In the respiratory organs of Ganoidei traces, more or less evident, remain of structures normally present in Plagiostomi and normally absent in Teleostei. These are (1) the spiracle, which represents the visceral cleft between the mandible and hyoid; (2) the pseudo-branchia, a gill-like, but non-aërating appendage,[1] representing the gill of the mandibular arch, the "spiracular gill" of Plagiostomi; (3) the opercular gill, equivalent to the pseudo-branchia of Teleostei and to the hyoid gill of Plagiostomi. The variations exhibited in the branchial apparatus of the Ganoids may be summarised thus:

	Spiracle.	Pseudo-branchia.	Opercular gill.
Acipenser	×	×	×
Polyodon[2]	×	×	
Polypterus[2]	×		
Lepidosteus[3]	...	×	×
Scaphirhynchus, Lepidosiren, Protopterus, Ceratodus[4]	...		×
Amia			

[1] Demme ('Das Arterielle-Gefässsystem von *Acipenser ruthenus*,' 1860) has maintained that in the Sturgeon the pseudobranchia is respiratory.

[2] In these genera the operculum receives a branchial artery, and hence Müller has conjectured that the gill may be present in an early stage of growth ('Fernere Bemerk. über d. Bau d. Ganoiden, Monatsb. Ak. Berl., p. 71, 1846).

[3] The *homology* of the pseudo-branchia in this genus is not perfectly clear.

[4] Not functional in *Ceratodus*.

Lastly, Müller gives the abdominal position of the ventral fins as an easy external mark of the Ganoid order. This is plainly not of great importance; it is the characteristic of one of Cuvier's sections of Teleostei or Osseous fishes, the Malacopterygii Abdominales. Moreover, since 1844, *Calamoichthys* has been brought to light, a Ganoid with no ventral fins at all. Müller seems to have contemplated such a contingency, as we see from the words: "Den Character von den abdominalen Bauchflossen halte ich bloss zeitweilig für bindend."

Such are the characters of the recent Ganoids included in the order by Müller. It must be added that, like the Elasmobranchii, they have a spiral valve in the intestine. This structure, the function of which is imperfectly known, may be described as an open spiral riband or ridge, very variable in its proportions, which lines the lower part of the intestinal tube, and in many cases its whole length. Müller speaks of it as not known in all Ganoids; *Lepidosteus* being an exception so far as he knew. Subsequent dissections have demonstrated the presence of a rudimentary, but strictly homologous structure in this genus also,[1] so that we may now regard the spiral valve as a fresh character of Ganoids, distinguishing them from all Teleostei, associating them more closely with Elasmobranchii.

The swim-bladder, whose physiological interest is so great in certain Ganoid fishes, yields also useful zoological characters. It is always present in this order, and always communicates by means of a *ductus pneumaticus* with the alimentary canal. It is single in most, but in *Lepidosteus* and *Amia* it exhibits an imperfect median septum or fold, while it is double in *Polypterus, Protopterus,* and *Lepidosiren.* In *Ceratodus, Lepidosiren, Protopterus, Lepidosteus,* and *Amia* the swim-bladder is more or less cellular, an interesting point of resemblance to the higher vertebrates, shared by some Teleostei (*Chirocentrus, Platystoma*). In *Polypterus* and *Acipenser,* probably in others, it is lined with ciliated epithelium.[2] The ductus pneumaticus opens usually, as in most of those Teleostean fishes which possess such a structure, on the dorsal surface of the œsophagus; it opens ventrally in *Lepidosiren, Protopterus, Ceratodus,* and *Polypterus,* while in *Acipenser* it communicates (as in the Herring) with the dorsal surface of the cardiac end of the stomach.

The essential reproductive organs (testis and ovary) of Ganoid fishes are not usually continuous with the efferent ducts (vas deferens or oviduct). The sexual elements are therefore, as a rule, liberated into the abdominal cavity, as in Elasmobranchs, Marsipobranchs, *Amphioxus,* and certain exceptional Teleostei (*Muræniдæ, Salmonidæ*). *Lepidosteus,* however, agrees with ordinary Teleostei in having the reproductive bodies continuous with the efferent ducts. The vasa deferentia and oviducts are not perfectly separate from the ureters, as in Teleostei, but are connected, in most Ganoids, by the

[1] Noticed in Müller's "Nachschrift," 'Abh. Berlin Akad. Wiss.,' 1844, p. 91. In *Amia* the valve is also imperfectly developed.

[2] Leydig, 'Zeits. für Wissensch. Zoologie,' vol. v, p. 64 (1854).

discharge of one into the other. Usually the male and female ducts open into the dilated ureters; in *Polypterus* the united ureters open into the united generative ducts. In Sirenoidei the ureters, separate or united, and the united generative ducts are received into an urogenital sinus which lies in front of the rectum, and opens in common with it. Abdominal pores, single or double, situate behind the anus, occur in all Ganoids.

It will be seen that the urogenital system furnishes characters by which the Ganoids are removed from Teleostei, and approximated to Elasmobranchii, but that the correspondence with the latter group is far from close.

Some of the less constant features of the Ganoids are available for subdivision of the order into groups adequate to the purposes of the zoologist if not of the palæontologist. *Amia*, *Polypterus*, and *Lepidosteus* are covered with scales and have a bony skeleton; the Sturgeons, *Scaphirhynchus*, and *Polyodon* are naked or only partially covered with osseous scutes, while their endo-skeleton is incompletely ossified, especially in the skull. These points of difference define two sections—the *Holostei* and the *Chondrostei* of Müller. We may employ for generic distinction the differences in the respiratory organs, already given in a tabular form, and the varying structure of scales and fins. *Amia* is cycloid; *Polypterus* and *Lepidosteus* ganoid in the sense of Agassiz. *Lepidosteus* and the Chondrostei have *fulcra* or imbricate, pointed scales attached generally to the front edge of some of the fins; *Amia*, *Polypterus*, and *Calamoichthys* have fins without fulcra. Most of the Ganoids have abdominal ventral fins; *Calamoichthys* has no ventral fins at all.

Müller's discoveries were sufficient to define the Ganoid order, to subdivide it into two convenient sections, and to arrange under these with just and precise definitions all the then known recent genera. It now remains to narrate briefly the progress of discovery since 1844, and to discuss the position of the Ganoids in the class Pisces as disclosed to us by further investigations.

The discovery of *Lepidosiren* and *Protopterus*, and the foundation thereupon by Müller of the order *Dipnoi*, are referred to at greater length under the genus *Lepidosiren*. This order was recognised as perfectly distinct until the announcement in 1870 of one or more living species of *Ceratodus*, and the revelation of its structure by Dr. Günther. The influence of this discovery upon systematic ichthyology must be shortly noticed in this place. Nearly all the characters of *Lepidosiren* and *Protopterus* assimilate them to the class Pisces. In that class evidence of their special relationship to the Ganoids, Sharks, and Rays, was afforded by their muscular and contractile bulbus arteriosus, the valves in its interior, and the spiral valve of the intestine. Owen, Hyrtl, and Huxley had remarked the points of agreement between *Lepidosiren* and the Ganoid *Polypterus*. The two genera were indeed referred to distinct orders of fishes mainly on account of the different function of the swim-bladder and the different position of the valves of the

bulbus arteriosus. *Ceratodus* now comes in to bridge the interval. It has the functional lung of *Lepidosiren*, the transverse arterial valves of *Polypterus*.

The relations of Dipnoi and Ganoidei consequently require fresh adjustment. It seems at present most satisfactory to treat the Dipnoi as a part of the Ganoid order, whose definition may be extended to include fishes having longitudinal valves in the bulbus arteriosus.

Dr. Günther has proposed[1] a further step, viz. to unite the reconstituted order Ganoidei with the Elasmobranchii, so as to form a new subclass—*Palæichthyes*. Solid reasons are adduced for this step, but its discussion is not needful in this place. The Ganoidei and Dipnoi may, for reasons subsequently given, be united, and their place is plainly next the Elasmobranchii. That the relations of the three groups are close will not be disputed by any zoologist.

The following list of recent Ganoids is taken, with trifling alterations, from Dr. Günther's 'Catalogue of Fishes,' vol. viii.

Protopterus, Ow.	1 species
Lepidosiren, Fitz.	1 ,,
Ceratodus, Ag.	2 ,,
Polypterus, Geof. St. Hil.	1 ,,
Calamoichthys, J. A. Smith . . .	1 ,,
Lepidosteus, Lacép.	3 ,,
Acipenser, Art.	19 ,,
Scaphirhynchus, Heck.	1 ,,
Polyodon, Lacép.	2 ,,
Amia, L.	1 ,,

We rank, then, among the Ganoidei the recent genera here enumerated, and such fossil forms as are more nearly connected with them than with other recent fishes. What these forms are it will be our task in the following pages to ascertain.

It is plainly necessary to follow some uniform nomenclature in describing the bones of the skull, which are usually the most instructive fragments of fossil Ganoids. It will also be conceded that the best available principle of classification of the elements, whether of the skull or of any other part of the animal framework, is that which rests upon embryology. The method of identification by relative position is too uncertain, and wholly fails us in very aberrant skulls, and sometimes even in the comparison of typical skulls. A nomenclature based upon the vertebrate theory of the skull is elegant and philosophical in form, but the serial homologies which it presumes have no demonstrated basis of fact. To found upon the development of the skull means, in the present state of our knowledge, to found upon Prof. Parker's memoirs. These invaluable writings, in which the views suggested by Prof. Huxley's 'Croonian Lecture'

[1] 'Phil. Trans.,' vol. clxi, pt. ii, p. 554 (1872).

(1858) and 'Elements of Comparative Anatomy' (1865) have been elaborated, extended and corrected, furnish a convenient set of terms, which will be employed in the present memoir.[1]

The following table may be found useful to those who have not been able to methodise for themselves the results of recent inquiries in this field :

I. The Occipital segment. (From cartilaginous occipital ring, derived from plates investing notochord, the *parachordals.*)[2]
- Basi-occipital (*axial*).
- Ex-occipital.
- Supra-occipital [Dermo-supra-occipital].

II. Otic Bones (ossifications of Otic capsule).
- Opisthotic (about, generally below, the arch of the posterior canal).
- Epiotic (arch of posterior canal).
- Pro-otic (fore-edge of capsule).
- Sphenotic (ampulla and arch of anterior canal).
- Pterotic (ampulla and arch of horizontal canal). [Dermal bones frequently unite with one or other of the periotic bones.]

*** The pro-otics may appropriate part of the investing mass and meet along the middle line (as in the Salmon), so as to simulate a cranial sclerotome.

III. Ossifications of Trabeculæ cranii and lateral cranial wall (trabecular crest).
- Basi-sphenoid (*axial*).
- [Parasphenoid].
- Ali-sphenoid.
- Pre-sphenoid (*axial*, absent in Fishes and Amphibia).
- Orbito-sphenoid.
- Mesethmoid (*axial*).
- Ectethmoid (pre-frontal).

IV. Ossifications of Palato-pterygoid arch. (Upper segment of mandibular arch.)
- Mesopterygoid.
- Pterygoid.
- Palatal.

[1] The original memoirs may be consulted in the 'Philosophical Transactions' (1869—1877) and 'Zoological Transactions' (1877). See also 'The Morphology of the Skull,' by Parker and Bettany (1877).

[2] The notochord is invested by the parachordals, but in certain types (Lamprey, Shark, Skate, Sturgeon, *Bombinator*, *Pseudis*) has its own sheath of cartilage.

[Vomer.]
[Pre-maxilla.]
[Maxilla.]

V. Ossifications of 1st Post-oral arch (Mandibular).
Metapterygoid.
Quadrate (Malleus of Mammalia).
[Squamosal = pre-opercular + supratemporal.]
Articular.
[Dentary.]
[Splenial.]
[Angular.]
[Coronoid.]
[Surangular.]

[V A. Membrane-bones of Opercular Fold.
Pre-opercular (not differentiated in Ganoids, except *Amia*).
Inter-opercular.
Opercular (*c.* Hyo-mandibular).
Sub-opercular.]

*** The pre-opercular and inter-opercular are related to the mandibular pier, the opercular and sub-opercular to the hyo-mandibular.

VI. Ossifications of 2nd Post-oral arch (hyoid).
* Anterior Division.
Hyo-mandibular (Incus of Mammalia and Columella of Amphibia. The Columella of Sauropsida = Incus + Stapes) (*c.* Opercular).
Symplectic (*c.* Quadrate).
** Posterior Division.
Stylo-hyal.
Epi-hyal.
Cerato-hyal.
Hypo-hyal.
Genio- or Basi-hyal.
[Branchiostegal Rays. Represented by cartilaginous rays in the Sharks and Skates.]

VII. Ossifications of 3rd Post-oral arch (branchial).
Pharyngo-branchial.
Epi-branchial.

Cerato-branchial.
Hypo-branchial.
Basi-branchial.
[Branchial Rays.]

The remaining branchial arches are successively smaller and their components less regular. The tooth-bearing and gill-less 5th branchial arch is known in Ichthyology as the "inferior pharyngeal bones."

The ossifications included in square brackets are membrane-bones, whose attachments are approximately represented by their place in the list.

The membrane-bones of the roof of the skull, representing, apparently, modified scales, can hardly be classified upon any more satisfactory basis than that of mere local relation. A tolerably constant median series consists of a dermo-supra-occipital (flanked on each side by a dermo-epiotic), a pair of parietals,[1] a pair of frontals,[1] and a pair of nasals.[1] The orbital ring often, especially in Fishes, yields a more or less complete chain of bones, of which the lachrymal is the most specialised. There may be post-orbital and supra-temporal bones behind the orbit, or a more numerous equivalent series. The maxilla may be connected behind to a jugal, and that again to a quadrato-jugal.

The normal position of various other membrane-bones has been indicated in the preceding table.

[1] These pairs, or some of them, may be consolidated into single bones.

Order GANOIDEI.

Sub-order Sirenoidei, *J. Müller*.[1]

Diphycercal. Vertical fin continuous. Paired fins acute-lobate, if scale-bearing and fringed; archipterygian. Scales cycloid. Dentition of palatal and mandibular plates with radiating ridges, and a pair of unopposed vomerine teeth. No gular plates or branchiostegals. Mandible autostylic. Air-bladder a functional lung, and nostrils opening into the mouth, in the recent species.

Family Protopterini, *Günther*.[2]

Paired fins long, slender, and pointed, supported by jointed, unbranched, cartilaginous rods, with or without lateral rays. Bulbus arteriosus with two longitudinal valves.

Genus Lepidosiren, *Fitzinger*.

Skull imperfectly ossified; no occipital condyles; two long bones continued backwards and upwards from the orbital region; separated from these by muscles is a prominent occipital crest. *Nasal foramina* double on each side; anterior pair inferior, in front of the mouth. Two ossifications of the opercular fold, which may represent *opercular bones*, attached to the quadrate. *Vertebral column* notochordal; neural arches ossified; hæmal arches occur towards the tail. Upwards of fifty pairs of *ribs*. *Pectoral arch* imperfectly ossified, connected with the ex-occipital bones above; clavicles ossified, united below by an epicoracoid cartilage. *Pelvic arch* cartilaginous, imbedded in ventral muscles, consisting of a median cartilage, continued on each side into a cruciform curved process, to the hinder ray of which the limb is articulated. *Teeth*.—Two pairs of opposed dentary plates, each with three angular ridges, adapted for cutting, and separated by two angular grooves. Anterior denticle ending in a sharp point; posterior surface broader and less elevated. Dentary plates consisting of dentine, and investing a bony base. Vomerine teeth

[1] 'Wiegm. Arch.,' 1843, p. 327.

[2] 'Phil. Trans.' vol. clxi, pt. ii, p. 555 (1872).

two, pointed, imbedded in the mesethmoid cartilage. *Pectoral fin* without fringe. *Ventral fin* without fringe. *Vertical fin* continuous. *Scales* cycloid, with a minute reticulate pattern, covering all the body except the fore- and part of the hind-limb. *Lateral line* central, extending from head to tail. *Branchial arches* five; no gills upon first, second,[1] or fifth in adult; no spiracle; no pseudobranchia; opercular gill rudimentary; no external gills as yet known. *Air-bladder* double, lung-like. *Heart* with two incompletely separated auricles; incomplete ventricular septum. *Optic nerves* not decussating. *Intestine* straight, with spiral valve; no distinction of large and small intestine; rectum communicating with urogenital sinus. *Oviducts* with dilated peritoneal opening; not united with ureters; entering urogenital sinus by a common opening. *Abdominal pore* single, in front of vent.

L. PARADOXA, *Fitz.*

Specific Characters.—Those of the genus.

Formation.—Recent.

Locality.—River Amazon and tributaries.

References.—Fitzinger, Isis, p. 379 (1837); Natterer, Ann. Wien. Mus., ii, p. 165, (1839); Bischoff, *Lepidosiren paradoxa*, anatomisch untersucht und beschrieben, Leipsic, (1840), translated in Ann. Sci. Nat., vol. xiv, p. 116 (1840); Hyrtl, Abh. Böhm. Gesell., vol. iii, p. 605 (1845); Heckel, Müll. Arch. Nat., p. 534 (1845); Duméril, Hist. Nat. des Poissons, tom. ii, p. 467 (1870); Günther, Catalogue, vol. viii, p. 322 (1870).

Genus PROTOPTERUS, *Owen.*

RHINOCRYPTIS, *Peters* (LEPIDOSIREN of many authors).

Pectoral and ventral fins fringed on the post-axial border by a cutaneous fold supported by rays, several of which spring from each joint of the axis. Three rudimentary *external gills* persist to the adult state. *Branchial arches* six; the first and sixth with a single gill, none on the second and third. About thirty-six pairs of *ribs*. In most other respects similar to *Lepidosiren*.

[1] Hyrtl found a gill on the posterior edge of the second arch in his example.

P. ANNECTENS, *Owen.*

P. ANGUILLIFORMIS, *Ow.*
R. AMPHIBIA, *Peters.*
P. ÆTHIOPICUS, *Heckel.*
L. ARNAULDII, *Castelnau.*
L. TOBAL, *Adams.*

Specific Characters.—Those of the genus.

Formation.—Recent.

Locality.—Rivers of tropical Africa, Gambia, Senegal, Niger, White Nile, Zambési.[1]

References.—Owen, Proc. Linn. Soc., p. 29 (1839); and Trans. Linn. Soc., vol. xviii, p. 327 (1841); Milne-Edwards, Ann. Sci. Nat. Zool., 2nd ser., vol. xiv, p. 159 (1840); McDonnell, Nat. Hist. Review, vol. vii, p. 94 (1860); Serres, Compt. Rend., Sept. (1863); Krauss, Jahresh. d. Vereins für Vaterländische Naturkunde in Württemberg, p. 126 (1864); Klein, *ib.*, p. 134; Duméril, Hist. Nat. des Poissons, tom. ii, p. 470 (1870); Günther, Catalogue, vol. viii, p. 322 (1870).

A good view of the skull (with description) by Cobbold, Proc. Zool. Soc., 1862, p. 120, pl. xiii. The muscles and cranial nerves are described in Humphry's Observations in Myology, p. 65, pl. v.

In 1837 a new fish was sent by Dr. Natterer to the Vienna Museum from the river Amazon. It was examined by Fitzinger, who named it *Lepidosiren paradoxa*, placing it, as we now see, erroneously, in the class of Reptiles, but calling attention at the same time to its piscine affinities. It completely resembled a fish in external form, except that attenuated processes, cylindrical and pointed, occupied the position of the pectoral and ventral fins. It further possessed persistent internal gills, and a spiral valve in the intestine, besides a vertebral column and an organ of hearing comparable only with those of a Fish. But it was found to be furnished with a three-chambered heart, nasal passages communicating with the mouth,[2] and a true paired lung, connected with the œsophagus by an air-duct closed with a glottis, and capable of aerating venous blood. This last hint as to its affinity was regarded for a time as decisive. The presence of a functional lung was then held to be the one test sufficient to separate the class Reptilia (= Reptilia + Amphibia of modern naturalists) from the class Pisces. *Lepidosiren*

[1] The occurrence of the species in different river-basins receives explanation from the physical geography of Africa. "Some of the plains we crossed are flooded to a depth of two or three feet during the rainy season, when the water extends completely across the watershed between the Zambési and the Kassabé. * * When flooded, these plains are overspread by numerous fish, consisting principally of a sort of mud-fish and a small minnow-like fry."—Cameron's 'Across Africa,' vol. ii, p. 168 (1877).

[2] Owing to the imperfection of his specimen, these were at first described as blind sacs by Professor Owen in his account of *Protopterus.*

possessed a functional lung, and was reckoned as a Reptile, or as what we should now more distinctively term a Perennibranchiate Amphibian.

Within two years from the publication of Fitzinger's new species (*Lepidosiren paradoxa*), another nearly allied animal from Senegambia was submitted to Prof. Owen for examination. He was at first disposed to regard it as a new genus, and in the Manuscript Catalogue of the Museum of the Royal College of Surgeons he assigned to it the name of *Protopterus*, but the perusal of Natterer's account of *Lepidosiren paradoxa* afterwards led him to unite the two species in one genus. Ultimately the points of difference appeared to be of generic importance, and the name of *Protopterus* was revived for what was first named in print *Lepidosiren annectens*. Meanwhile Peters[1] had proposed the name of *Rhinocryptis*, which is thus a third synonym in use.

Professor Owen came at once to the conclusion that *Lepidosiren* and *Protopterus* were not Amphibia, but Fishes, resting this conclusion on the supposed absence of any communication between the nasal sacs and the mouth. A long controversy ensued, in the course of which every part of the structure of the fishes in question was minutely scrutinised. The amphibian determination was supported by Natterer, Fitzinger, Bischoff, and Gray.[2] Milne-Edwards less decidedly took the same side. Agassiz,[3] Müller, Hyrtl, and Peters[4] regarded the piscine characters as predominant, and their arguments have finally prevailed.

It is not needful to review in all its details an extinct controversy. *Lepidosiren* and *Protopterus* present the following decisive characters, each found in unquestioned Fishes, and none in any recent adult Amphibian or Reptile:

1. Persistent notochord; no intervertebral cartilages.
2. No occipital condyles; notochord entering the skull.
3. Vertical fin-rays.
4. Dentition consisting of a pair of vomerine teeth, and two pairs of opposed dental plates.
5. Persistent internal gills.
6. No distinction of large and small intestine.

The *Protopterus* of Tropical Africa is now known to frequent the river Gambia, the Senegal, Niger, Zambési and Nile. All these streams are more or less intermittent. When the waters retreat the *Protopteri* which may be left upon the bank bury themselves in the mud, leaving however a small aperture for communication with the air. As the mud dries and cracks in the sun the fishes become enveloped in earthy cases lined by a thick mucous secretion. In this state they remain until the return of the rainy season enables them to escape and swim about again. The more obvious pecu-

[1] 'Monatsbericht der Akademie der Wissenschaften zu Berlin,' 1844, p. 414.

[2] 'Proc. Zool. Soc.,' 1856, p. 342.

[3] 'Poissons Fossiles,' vol. ii, pt. ii, p. 46.

[4] 'Müller's Archiv.,' 1845, §§ 1—14. For further references, see pp. 13, 14.

liarities of these curious fishes seem to depend largely upon their exceptional vital conditions. During the torpid state respiration is carried on by the swim-bladders, which temporarily discharge the function of lungs, receiving imperfectly venous, and returning arterial blood. When the rising of the water permits the fish to resume aquatic habits, the gills oxygenate the blood, and the swim-bladder receives arterial blood for nutrition only. *Lepidosiren paradoxa* is similarly adapted for both atmospheric and aquatic respiration.

The discovery of *Lepidosiren* and its African ally *Protopterus* has been in every way most important. The homology of the swim-bladder of the Fish with the lung of the Reptile, maintained long before by Harvey and Hunter, became clear enough now that the important connecting link was supplied of a Fish's swim-bladder receiving venous and returning arterial blood. The definition of the class Pisces became more comprehensive, and their affinities to the higher vertebrata more apparent. From this time zoologists began to remark the many points of resemblance between Fishes and Amphibia (which had been commonly placed among Reptiles). Hitherto the appearance of lungs in the adult had marked in the systems of naturalists the passage from the lower to the higher division of cold-blooded vertebrates. The absence of gills in all stages was henceforth the distinctive character of the higher groups, and zoologists began to associate the Fishes with the Amphibia, and the Reptiles with the Birds, a distribution which has since been fortified by many arguments drawn from osteology and development.

The peculiarities of *Lepidosiren* and *Protopterus* seemed so striking that when their place among Fishes was conceded they ranked as a separate order (Dipnoi of Müller).[1] Attempts were made to connect them with other orders of Fishes with various success. Some systematists were perplexed by the affinities of *Lepidosiren* to several types of piscine structure, as well as to the higher class of Amphibia. Professor Owen appears to have seen fully their relationship to the Ganoids. The following sagacious and comprehensive sentence illustrates his views.

"It is extremely interesting to find the Ganoid *Polypterus*, which of all osseous fishes most closely resembles the *Lepidosiren* in its spiral intestinal valve, in the bipartition of the long air-bladder, the origin of the arteries of that part, and the place and laryngeal mode of communication of the short and wide air-duct or windpipe, also presenting the closest agreement with the *Lepidosiren* in the important character of the form of the brain."[2]

Not only was the general affinity of the Dipnoi to Ganoidei thus clearly anticipated, but fairly successful attempts were made to indicate their nearest allies in that order. In 1839 Professor Owen[3] described the teeth of *Protopterus* as resembling "in their paucity, relative size, and mode of fixation to the maxillæ, those of the *Chimæra*, and

[1] 'Abhandlungen der Akademie der Wissenschaften zu Berlin' (1844).

[2] 'Comp. Anatomy of Vertebrates,' i, p. 499 (1866).

[3] 'Linnean Transactions,' vol. xviii, pt. ii, p. 331 (1839).

some of the extinct cartilaginous fishes, as *Cochliodus* and *Ceratodus*." In 1861 Prof. Huxley,[1] while discussing the classification of Devonian Fishes, was led to notice the resemblance between the fins of the Crossopterygian Ganoids and those of *Lepidosiren* (*Protopterus*). One passage of considerable historical interest is here cited.

"Without wishing to lay too much stress upon the fact, I may draw attention to the many and singular relations which obtain between that wonderful and apparently isolated fish, *Lepidosiren*, sole member of its order, and the cycloid Glyptodipterine, Ctenodipterine, Phaneropleurine, and Cœlacanth Crossopterygidæ. *Lepidosiren* is, in fact, the only existing fish whose pectoral and ventral members have a structure analogous to that of the acutely lobate, paired fins of *Holoptychius*, of *Dipterus*, or of *Phaneropleuron*, though the fin-rays and surface-scales are still less developed in the modern than in the ancient fish. The endo-skeleton of *Lepidosiren*, again, is, as nearly as possible, in the same condition as that of *Phaneropleuron*, and is more nearly similar to the skeleton of the Cœlacanths than that of any other recent fish; while, perhaps, it is not stretching the search for analogies too far to discover in the stiff-walled lungs of *Lepidosiren*, a structure more nearly representing the ossified air-bladder of the Cœlacanths than any with which we are at present acquainted, among recent or fossil fishes. Furthermore, *Lepidosiren* is the only fish whose teeth are comparable in form and arrangement to those of *Dipterus*. Though *Lepidosiren* may not be included among the Crossopterygidæ, nor even in the order of Ganoidei, the relations just pointed out are not the less distinct; and, perhaps, they gain in interest when we reflect, that while *Polypterus*, the modern representative of the rhombiferous Crossopterygidæ, is that fish which has the most completely lung-like of all air-bladders, *Lepidosiren*, which has just been shown to be, if not the modern representative of the cycliferous Crossopterygidæ, yet their 'next of kin,' is the only fish which is provided with true lungs. These are unquestionable facts. I leave their bearing upon the great problems of zoological theory to be developed by every one for himself."

The later discoveries which seem to have established the position of *Lepidosiren* and *Protopterus* among the Ganoids will be related under the heading *Ceratodus*. Meanwhile it will be seen that the Dipnoi are in many of their characters reconcileable with the definition of *Ganoidei* put forth by Müller in 1844. The optic nerves do not decussate, the intestine has a spiral valve, the branchiæ are free, the ventral fins are abdominal. The most notable differences relate to the heart, for the organs directly related to habitat give scanty information as to affinity, while the other and more striking points of difference which might be cited concern parts which vary greatly among undoubted Ganoids. The Ganoids have rows of transverse valves in the bulbus arteriosus, and but one auricle; the *Protopterini* have two longitudinal valves in the bulbus arteriosus, and two auricles. The presence of an auricular septum will not appear of too great importance to those who reflect upon its varying degrees of development in Amphibia. Possessed of an

[1] 'Decades of the Geological Survey,' x, p. 26.

ample knowledge of the structure of *Lepidosiren* and *Protopterus*, Müller rested the definition of his new sub-class, Dipnoi, upon the following characters :[1]—Scaly fishes *with both lungs and gills, and nostrils communicating with the mouth. Valves in bulbus arteriosus placed longitudinally and spirally.* Spiral valve in intestine. Oviducts opening into abdominal cavity. Vertebral column with notochord and attached apophyses. The two sentences in italics contain the marks which Müller understood to distinguish Dipnoi from Ganoidei, and of these the first relates to adaptive characters alone.

Family Ceratodontini, *Günther.*

Paired fins developed as broad, pointed paddles, supported by jointed, cartilaginous, axial rods, which give off jointed rays on each side. Bulbus arteriosus with valves in three transverse series.

Genus Ceratodus, *Ag.*[2]

Skull.—A cartilaginous primordial skull, continuous with vertebral column, partially ossified, covered from side to side by a bony shield, which is made up of two median and several lateral plates. The temporal muscles separate the hind part of this shield from the primordial skull. Palato-pterygoid ossified, supporting a dental plate, and articulating with a downward process from the frontal part of the cranial roof. Suspensorium chiefly cartilaginous; a quadrate (?) ossification on its outer side; hyomandibular very small, unossified. Vomer represented only by the bony base of the "vomerine" tooth. A large lozenge-shaped parasphenoid, enclosed between palato-pterygoids in front, and extending backwards to about the level of the fourth vertebra. Nasal foramina two on each side; the anterior in front of the mouth, inferior; the posterior external to palatal dentary plates, partly surrounded by small labial cartilages. Opercular and inter-opercular bones. Pre-opercular (?) united to bony shield. Mandible short, with wide symphysis; autostylic. Dentary, splenial, and angular pieces, the splenial supporting

[1] 'Abh. Ak. Wiss. Berlin,' 1844, p. 198.

[2] It is my pleasant duty to return thanks for much kind help in the study of this genus. The Earl of Enniskillen, Sir Philip Egerton, Mr. E. B. Tawney and the Directors of the Bristol Museum, Dr. Oldham, late Director of the Geological Survey of India, Mr. W. Davies, of the British Museum, and Mr. E. T. Newton, of the Geological Survey of England, have allowed me to study the collections in their possession or under their care to the greatest advantage, and have also, in some cases, materially assisted me by information and advice.

a dental plate, and the angular giving off a coronoid process. Branchiostegals unossified, gular plates none. *Teeth.*—A pair of vomerine cutting teeth; palatal and mandibular dental plates, ankylosed to bone. Dental plates composed of dentine, rising into folds or ridges externally, anterior end broader and more elevated, inner border smooth; punctate, minute structure tubular; pulp-cavity persisting in the centre of each plate until the individual is nearly adult. *Vertebral column* notochordal; neural and hæmal arches ossified except at the ends; bearing neural spines, inter-neurals, and in the vertical fin a double row of cartilaginous dermo-neurals. About twenty-seven pairs of ribs. The hæmapophyses united in the caudal region, and bearing hæmal, inter-hæmal, and a double row of cartilaginous dermo-hæmal spines. *Pectoral arch.*—A supra-scapula attached to skull, and forming the posterior wall of the gill-chamber; clavicle large, partly cartilaginous, the bony investment divided by a transverse suture. *Pelvic arch.*—A single pelvic cartilage giving off two processes on either side, of which the lower supports the limb. *Pectoral fin.*—Acute lobate, a broad fringe of fin-rays on the pre-axial and post-axial borders. *Ventral fin* similar; abdominal. *Vertical fin* continuous from the middle of the back to the vent, diphycercal. *Scales* large, cycloid, faintly sculptured, calcified externally. *Lateral line* extending from head to tail, nearly central. *Heart.*—Bulbus arteriosus imperfectly two-chambered, with one or two transverse rows of perfect valves, and three or two rows of imperfect valves behind; an incomplete ventricular septum; no auricular septum. *Branchial arches* five, of which four bear gills; the gills attached beyond the branchial arches to the outer wall of the gill-chamber. No mandibular pseudo-branchia; no spiracle; opercular gill (not functional). *Lung* single, cellular, with duct and glottis. *Intestine* with spiral valve. *Ovaries* lamellated, unconnected with oviducts. *Abdominal pores* two, behind the vent. *Oviducts* and *vasa deferentia* unconnected with ureters. *Optic nerves* not decussating.

References.—Agassiz, 'Poisson Fossiles,' vol. iii; Günther, 'Phil. Trans.,' vol. 161, part 2 (1872); Krefft, 'Proc. Zool. Soc.,' 1870, p. 221; Huxley, 'Proc. Zool. Soc.,' 1876, p. 24. The muscles are described in Humphry's 'Observations in Myology,' p. 91.

The genus *Ceratodus* was first described by Agassiz[1] from scanty materials derived from Aust Cliff on the Severn, from the Trias of Germany, and from the Oolite of Stonesfield. Only the teeth were known, and of these nearly every example seemed to offer features peculiar to itself. Out of seventeen specimens known to him, Agassiz selected fourteen as types of possibly distinct species. He decided from the form of the teeth that they must have been set in opposed pairs, one on each side of the mouth, that the denticles were external, and the narrow end foremost. The substance of the tooth he found to consist of tubular "enamel" (dentine) investing a bony base. The zoological position of *Ceratodus* was hard to determine. Agassiz was at first disposed to place it near *Psammodus*, but when he found reason to attribute to the new genus not several rows of teeth, as in *Psammodus*, but one pair only in each jaw, he inclined to

[1] 'Poissons Fossiles,' tom. iii, p. 129 *et seq.* (1833-43).

compare it with the Cestracionts. At a later time he more plausibly referred *Ceratodus* to the *Chimæridæ*.[1] From their occurrence together in the Rhætic beds of the Severn, Agassiz hinted that the spines named *Nemacanthus* might belong to the same fish.

Perhaps no other palæontologist could have better interpreted the remains in question. It appears that such criticism as was offered was either unimportant or mistaken.[2] Putting aside for further consideration the questions of the zoological position of *Ceratodus* and the number of species, we may here remark that Agassiz was right as to most of his conclusions, distinctly wrong only as to the anterior and posterior ends of the teeth. His conjecture respecting *Nemacanthus* has proved unfounded.

We are no longer obliged to divine the structure of *Ceratodus* by means of obscure fossil remains. In 1870 the genus was ascertained by Mr. Gerard Krefft to be still extant in the rivers of Queensland. Specimens transmitted to Europe have been carefully described by Dr. Günther,[3] and, though difficulties yet remain, the general structure of the fish is fairly well known.

The disposition of the teeth in this genus is now ascertained to be as follows:—An osseous palato-pterygoid arch supports two palatal dental plates, whose horns or denticles project outwards, the larger and more prominent being anterior. In advance of these are two cutting-teeth imbedded in the "vomerine" (mesethmoid) cartilage. The mandible supports a similar pair of dental plates. These are attached by their inner edges to the splenial bone, which invests the inner side of the jaw, while on the outer side they overlie the cartilaginous centre of the ramus, and to some extent the angular bone, with which they have a fibrous connection. In biting, the ridges of the dental plates interlock, though the opposed surfaces are not so accurately adjusted as altogether to prevent a sliding movement; the vomerine teeth are unopposed. All the dental plates are ankylosed to the supporting bones.

In the recent species the palatal tooth bears six distinct horns, and the inner margin is prolonged backwards as an imperfectly developed seventh. The first mandibular horn is received between the first and second palatal horns, the last mandibular between the sixth and the (imperfect) seventh of the palatal. This rule would enable us to distinguish readily between the fossil palatal and mandibular teeth, were the number of horns known in all the species. But we find nearly all the fossils to possess either four- or five-horned teeth, and we cannot at once tell how far the number is related to specific difference. Two difficulties occur at once, each of which complicates the other.

In order to trace gradations and discover gaps in the numerous fossil examples, we require to know that we are comparing similarly placed teeth. On the other hand, till the gradations and gaps have been so far investigated that species are satisfactorily defined, we cannot well test our rules for distinguishing upper and lower teeth. In

[1] 'Poissons Fossiles,' vol. i (introduction), pp. xxxvii, xxxix, xlix.

[2] See, for example, Plieninger ('Paläontologie Württembergs,' p. 88).

[3] 'Phil. Trans.,' 161, pl. ii (1872). See also Prof. Huxley in 'Proc. Zool. Soc.,' 1876, p. 24.

studying the rich collection of the Bristol Museum I have found these difficulties very real and troublesome. Other tests, such as the proportion of length to breadth, convexity or concavity of grinding surface, have been tried, but with no great practical success. Agassiz suggested that the flatter and broader forms may be palatal, and the narrower teeth with more elevated horns mandibular, or *vice versâ*. All such relative tests are of uncertain value, until the species and their range of variation are well known.

A collection of fossil *Ceratodus* teeth from Malédi, Central India,[1] has suggested the true key to this small but interesting problem. The Malédi teeth were in good preservation, and certain of them showed recognisable fragments of attached bone. The splenial buttress could be identified in some,[2] and a boss of bone, corresponding accurately to that pedicle, which in the recent fish passes upwards from the palato-pterygoid towards the frontal region, could be made out in others.[3] Further, as Dr. Oldham had previously remarked, pairs of these teeth could in certain cases be fitted perfectly together. It was plain that such teeth had been opposed, and had belonged, if not to the same individual, at least to the same species. It is found that in all cases the teeth recognised as palatal have one denticle more than the corresponding mandibular teeth, while they are ordinarily somewhat broader and flatter. Of the fossils in the Bristol Museum not a few have still attached to them bones precisely similar to those of the mandibular teeth from Malédi.[4] These we may now take for mandibular teeth. They have each four horns and no trace of a fifth. There is another group with a more or less rudimentary fifth denticle, which differs also in having the first denticle of such form that it could never have been received between two grinding surfaces.[5] These are plainly palatal teeth. Again, teeth of the species *C. runcinatus* and *Gulielmi* from the Muschelkalk have more than once been found with attached bone.[6] Here also the fossil palatal teeth are more or less perfectly five-horned, the mandibular four-horned. There is therefore, so far as we know, a rule applicable to all the fossil species hitherto described, making allowance for a few examples, probably exceptional individuals, which have fewer than four horns. This rule may be stated thus:—*The mandibular teeth are slightly smaller and narrower than the palatal, with no more than four horns in the fossil species. The first denticle is often prismatic, or adapted to two grinding surfaces. The palatal teeth have, usually, in the fossil species either five horns, or four and a trace of a fifth.*

The close association of *Ceratodus* with *Lepidosiren* and *Protopterus* is admitted by all zoologists; but it is not so universally conceded that the place of the three genera is

[1] See Dr. Oldham, "On some Fossil Fish Teeth of the Genus *Ceratodus* from Malédi, south of Nagpur," 'Mem. Geol. Survey of India,' vol. i, p. 295 (1859); and Miall, "On the Genus *Ceratodus*, with special reference to the Fossil Teeth found at Malédi," 'Palæontologia Indica' (1877).

[2] Plate V, fig. 11 *b*; Pl. III, figs. 3 *a*, 3 *b*. [3] Pl. V, fig. 12 *b*. Compare Pl. III, fig. 5 *c*.

[4] Pl. III, fig. 2. [5] Pl. IV. [6] Pl. III, figs. 4 *a*, 4 *b* (mandibular).

with *Dipterus* and *Ctenodus*, or with the Ganoids at all. Prof. Huxley[1] has lately indicated a new distinction, which he considers of systematic importance, in the different methods of suspension of the mandible. In some Ichthyopsida, *ex. gr.* Amphibia, *Chimæra*, Marsipobranchii, and Sirenoidei, the mandible is connected with the skull by a palato-quadrate suspensorium, which may be ossified or not, derived from the first postoral (mandibular) arch. Hence such skulls are named '*autostylic*.' In '*hyostylic*' skulls, on the other hand ('Ganoidei, Teleostei, and ordinary Plagiostomes'), "the palato-quadrate cartilage is no longer continuous with the chondrocranium (though the bony elements of that arch may unite suturally with those of the skull, as in the Plectognathi), but is, at most, united with it by ligament. Moreover the dorsal element of the hyoidean arch, or the hyomandibular, usually attains a large size, and becomes the chief apparatus of suspension of the hinder end of the palato-quadrate cartilage with the skull."

Ceratodus differs from the Ganoids also, according to Prof. Huxley, in the proportions of the parts of the brain. We need not as yet insist upon this point. It differs also from *Lepidosiren*; and until the test of cerebral proportions has been more extensively employed in the arrangement of fishes, we are ignorant of its real weight.

It is more needful to observe that the Sirenoidei differ from *Polypterus*, the only recent Crossopterygian Ganoid, in the absence of gular plates and in the presence of an archipterygium, or jointed cartilaginous rod, articulated with the pectoral arch, and giving off jointed radii with tolerable symmetry on both sides. Hence a line may be drawn somewhere between the Sirenoidei and *Polypterus*; and Prof. Huxley concludes "that it is better to retain the Müllerian groups of Dipnoi (*Sirenoidei*, Müller), Ganoidei, Teleostei, Plagiostomi, and Chimæroidei (*Holocephali*, Müller) as equivalent and distinct natural assemblages."[2]

There are of course forms nearer to *Ceratodus* and its allies than *Polypterus*. *Dipterus* and *Ctenodus* are two of these; and it is not easy to say whether the resemblances or the differences between the Dipnoi and the Ctenododipterini are of greater weight.

We do not know for certain that *Dipterus* and *Ctenodus* are hyostylic; but the suggestion has a certain degree of probability, and it may be worth while to offer some remarks upon the classificatory value of this character. The carrying backwards of the mandibular arch to the hyo-mandibular or uppermost piece of the hyoid arch serves, like the loose connection of the palato-quadrate, to enlarge the gape.[3] It is an adaptive

[1] 'P. Z. S.,' 1876, pp. 40 *et seq.*

[2] *Loc. cit.*, p. 57.

[3] "In all Teleosteans, and in some to a most extreme degree, the gape of the mouth is placed at a great distance from the head. In such fishes as the Dory (*Zeus*), in *Epibulus*, in *Fistularia*, and in the 'Hippocampoids' there is found the extreme of Teleostean modification of the mouth; but in the most moderate degree of specialisation, as in the Salmon, the hinge of the jaw is carried away from the head, first,

structure, providing for a more plentiful and rapid ingestion of food, and also for a greater rush of water over the gills. If we compare the conditions of life we may get fresh light upon the modification of the visceral arches which distinguishes the Teleostei and most of the Ganoids and Elasmobranchs from the Dipnoi. Isolated river-fish, feeding upon plants, small mollusks, and other stationary or slow-moving food, *Ceratodus* and *Lepidosiren* retain a nearly primitive disposition of the visceral skeleton.

This comparatively sluggish life also suffers the Dipnoi to retain a somewhat ineffective and not wholly aquatic respiration. *Ceratodus* has fixed gills with a single not very extensive opening behind. *Lepidosiren* also has a decidedly small passage for the exit of water. In Elasmobranchs we find fixed gills, and these more rigid than in *Ceratodus;* but a series of clefts unimpeded by an operculum [1] leads directly outwards from the respiratory chamber, and these clefts the lateral undulations of the fish open and close incessantly.[2]

While the Plagiostomi have in this way become adapted to an active and predatory life, other fishes, Teleostean or Ganoid, unrestricted in range and subject to fierce competition, have in remote times assumed the form of mouth which permits the most expeditious feeding. With greater activity there has simultaneously arisen a greater demand upon the respiratory apparatus; and in these fishes we find provision for a copious flow of water over the gills. The gape is usually large; and the opercular slit opens below as well as behind. With a mouth adapted for hasty and indiscriminate feeding we find correlated, in most Teleostei, a special masticatory apparatus placed in the throat upon the pharyngeal bones. Here again is an adaptive structure; and its small value for classificatory purposes has already appeared from attempts to found orders of Teleosteans upon the presence and arrangement of this accessory apparatus.[3]

It may perhaps be supposed that the displacement of the suspensorium, though an adaptation, is an adaptation of so highly special a kind, that it can hardly have arisen independently in different animals, and that it thus implies a common origin, not shared by others, for those species in which it occurs. This view would lead us to divide Pisces into one primary group to include Ganoidei (exclusive of *Ceratodus* and *Lepidosiren*), Teleostei and Plagiostomi (exclusive of *Chimæra*); and secondly, a group or groups comprising all the rest. I think that the point will not be pressed so far. There are

by a double condition of the quadrate, and, secondly, by the descent of the top of the pier away from the side of the head and its attachment some distance down to the overgrown pier of the next arch. All this modification shows that the Teleosteans are Vertebrates specialised to the uttermost for their own kind of life, and that they are, indeed, one of the culminating branches of the vertebrate *Life-tree.*" (Prof. W. K. Parker, "On the Development of the Skull in the Salmon," 'Phil. Trans.,' vol. clxiii, pt. 1, p. 110 (1873).

[1] *Chimæra* and its ally *Callorhynchus* have a rudimentary operculum.

[2] This action may be studied wherever Dog-fish are kept in an aquarium.

[3] Günther's 'Catalogue of Fishes,' preface to vol. iv.

important differences between *Ceratodus* and *Dipterus*, of which perhaps the most obvious are the diphycercal tail of the first and the heterocercal tail of the second; but we cannot entirely cut the two genera off from each other. Nor can we, I think, admit that the Ganoidei, Plagiostomi, and Teleostei have had a common ancestor from which *Ceratodus* and *Lepidosiren* derive no lineage. It remains for future investigation to draw the lines of connection and separation with their exact strength as well as in their true place. From such data as are now accessible it would appear that, on the whole, the Sirenoidei are more widely separated from other autostylic Ichthyopsida (such as Amphibia and *Chimæra*) than from the Crossopterygian Ganoids.[1]

In defence of this position it may be urged that another adaptation at least equally special with the displacement of the suspensorium, viz. the very peculiar dentition, connects together the four genera *Ceratodus*, *Lepidosiren*, *Dipterus*, and *Ctenodus*, while these are associated, not only with one another but also with the acute-lobate Crossopterygian Ganoids, by the structure of their paired fins. This last feature of resemblance, unimportant enough on the physiological side, seems to have no inconsiderable classificatory importance; and though the presence or absence of scales upon the fin does not mean much, yet the acute-lobed patch seems as yet to connect together only fishes between which some close affinity may be supposed to exist.

The arguments for and against the near alliance of the Dipnoi with *Dipterus* and *Ctenodus* are summarised in the following table:—

Paired fins acute-lobate, fringed;[2] dentition of opposed pairs of radiately ridged plates and an unopposed pair of vomerine teeth; nasal passages opening into the mouth [Ctenodus ?]; no ossified branchiostegal rays.	A.	
	Lepidosiren, *Protopterus*, *Ceratodus*	Autostylic; no gular plates; archipterygium; diphycercal.
	B.	
	Dipterus ... *Ctenodus* ...	Hyostylic ?; gular plates; archipterygium ?; heterocercal (*Dipterus*).

It is not known whether *Dipterus* and *Ctenodus* are hyostylic or autostylic; but *Polypterus* is hyostylic. It is not known for certain whether *Dipterus* and *Ctenodus* have an archipterygium or an ichthyopterygium; but the outward resemblance of the fins of *Dipterus* to those of *Ceratodus* renders it probable that they have an archipterygium.

[1] Prof. Huxley's table ('P. Z. S.,' 1876, p. 59) is apparently not intended to comprehend all the data essential to a true view of the affinities subsisting between different Ichthyopsida. It is introduced (p. 58) as a "mode of stating the facts of morphology in a condensed and comprehensible form, which shall be purely objective and free from speculation."

[2] *Lepidosiren* and *Protopterus* can only come under this definition by a considerable stretching of the words. It has already been explained what the structure of the paired fins in these genera really is. The analogy between the paired fins of *Protopterini* and those of the acute-lobate Crossopterygii was pointed out by Prof. Huxley in his 'Essay on the Classification of Devonian Fishes,' p. 26 (1861). The fins of *Ctenodus* are not known. In *Lepidosiren* the paired fins are not fringed.

The known difference between A and B relates, then, to the presence or absence of gular plates—a point sufficient to denote a family, but hardly of ordinal value. I am inclined to hold that, on the whole, A and B are not ordinally separable, but that they represent two families or suborders of Ganoids, which may continue to be called Sirenoidei (Dipnoi) and Ctenododipterini. According to present knowledge we may arrange such a series as this, extending between the Plagiostomi and the Teleostei :—

PLAGIOSTOMI.

Chimæra.

GANOIDEI. { *Lepidosiren.* *Ceratodus.* / *Dipterus.* *Ctenodus.* / Crossopterygii. / Lepidosteidæ. Acipenseridæ. Amiadæ. } GANOIDEI.

TELEOSTEI.

This series is interrupted by many gaps, of which that between *Chimæra* and *Lepidosiren* is perhaps the most considerable. Although the dentition is capable of being described in nearly the same terms in both genera, it differs greatly in details and proportions; and the absence of scales, the entirely cartilaginous skull, the absence of a swim-bladder, and the claspers of the male, separate *Chimæra* very decidedly from the existing Dipnoi.

The dental plates of *Ceratodus* are the sole means of discriminating the fossil species, and were till lately the only source of information respecting the genus itself. There is a palatal pair attached to the pterygo-palatine bones, and a similar pair in the mandible, receiving support from the splenial, and directly or indirectly from the angular bone. In the recent species the connection with the angular bone is by connective-tissue only, and the bony attachments of all the dental plates, though extensive, are so slight that they are readily detached without fracture. This was apparently the case with many of the Triassic species. Sometimes, however, we find a fossil tooth which retains a part of its bony base. Such specimens are figured in Pl. III. We owe to these rare examples the means of certainly distinguishing the palatal from the mandibular plates. In figs. 1—4 the splenial element can be identified, while on the outer and upper side of the palatal teeth (fig. 5) a boss of bone, which passes up towards the frontal region, is to be distinguished.

The only constant difference between the palatal and mandibular dental plates seems to lie in the number of denticles. In nearly all the recent and fossil examples which can be certainly identified as belonging to either category there is one denticle more in the upper than in the lower.

The tips of the denticles are external, and the larger denticles are in front, so that any tooth can be readily assigned its true place in the mouth.

Do similarly situated teeth succeed one another vertically? or were the young

and small teeth consolidated and enlarged by addition of fresh substance into those of the adult? We have as yet no direct information on these points, but it is highly probable that there was no replacement. If they were hard from the first, and replaced as they became too small, we should expect to find abundance of the small shed teeth. This is not the case, and nearly all are of what may be considered the adult size; besides, it is easy to see that great temporary inconvenience would result from the sudden loss of all the grinders, while replacement one by one would lead to distortion, and almost equally cripple the masticating power. If, on the other hand, the teeth were hard from the first, and enlarged by successive additions, this could only take place along the outer edge if the function of the teeth were maintained during its growth. Upon this supposition the angle, as the first formed part, should be greatly worn, while lines of growth should be apparent upon the surface. Neither of these indications can be traced either in the recent or fossil teeth. It is probable that the tooth was at first comparatively soft and vascular, that it grew, replaced the loss from wear, and changed its figure as requisite, becoming fully calcified and rigid only in the adult. When this point was reached, further increase could take place only by the addition of fresh layers to the base.

Such a dentition is plainly adapted to a herbivorous diet, and this conclusion is established by observation of the recent species.[1] The arrangement resembles in its general features that of a Ruminant mammal, except that the incisors are in the upper instead of the lower jaw, a point of difference which may be due to the circumstance that the Sirenoid approaches the plants upon which it feeds from below, the Ruminant from above.

When in use the first mandibular denticle is received into the first palatal furrow. The chief contact of the two sets of teeth is apparently between the tips of the ridges of the lower and the corresponding hollows of the upper. Hence the palatal denticles are usually less worn than those of the mandible, while the first mandibular denticle is commonly much worn and the corresponding hollow deep and extensive. Evidence of wear is often to be found also in both sets upon the angle and the internal margin posterior to the angle.

The British species of *Ceratodus* range from the Keuper to the Oolite. *C. lævissimus* (a MS. species of unknown authority) comes from the Upper Keuper sandstone of Ripple, Worcestershire, and *C. Phillipsii*, Ag., from the Stonesfield Slate. It is unfortunate that the latter specimen, like some others upon which specific determination partly rests, can no longer be found. I see no reason to doubt the express statement of Agassiz[2] that such a fossil did exist, confirmed as it is by Phillips himself.[3] Among fossils purchased by the British Museum from the Mantell collection is a *Ceratodus* tooth imbedded in an

[1] In the stomach of a recent *Ceratodus* I find much vegetable matter, and also some bivalve mollusca (*Cyrena*).

[2] 'Poissons Fossiles,' t. iii, pp. 135, 176.

[3] 'Manual of Geology,' table on p. 324 (1855).

Oolitic matrix, and probably derived from the same locality. The remaining British species come from the Rhætic beds of the Severn. The bulk of the great collections made by Higgins and others are assembled in the Bristol Museum, but useful series are possessed by the British Museum and the Museum of Practical Geology.

Among the 350 fossil *Ceratodus* teeth of the Bristol Museum a number of examples seem to be recognised at the first glance as specifically distinct. Some are extremely broad, others narrow; many have the first denticle much elevated, in others all the denticles are more or less elevated, a few are nearly plane. Strong pitting is usually apparent, but in occasional examples the surface is smooth to the eye, and presents a minute punctation only when closely examined. The curvature of the grinding surface, the thickness of the dentinal layer, and the length of the transverse ridges vary just as conspicuously. It is not surprising that Agassiz, dealing with a few only of these variable forms, should have found nearly every one specifically distinct.[1] Where specimens are few the naturalist is driven to use specific characters of whose systematic value he is ignorant. Even now that the collections have increased so greatly I have found it no easy task to discover the natural gaps in the series, and after nearly two years' study I was prepared to define five or six species where I now see only two. Still earlier, when entering upon the examination of the Bristol collection, the limits of species seemed impossible to be traced. Nearly every tooth had features of its own; there was no rule for distinguishing palatal from mandibular teeth, nothing known about succession, nothing about the effect of age upon the dentition. The only means of clearing up these difficulties was to put like things together, and find out by perpetual comparison what gradations of structure existed. In the progress of this tedious but necessary work, the Ceratodonts from the Deccan came to remove one perplexity, and henceforth it was possible to distinguish palatal from mandibular teeth.[2] The question of succession also was disposed of, though not so conclusively as one could wish.[3] After many abortive attempts, which revealed the untrustworthiness of nearly every character hitherto relied on, it was found possible to arrange the almost infinitely varied forms—large and small, long and short, broad and narrow, of all shapes, and of different thickness—in two series, each free from disturbing intervals. In the absence of a rich supply of specimens this reduction could not have been made, or at best must have been made on unsatisfactory grounds—an argument for the retention in public collections of what to an uninterested visitor are mere duplicates.

For the two species which thus emerged from a perplexed multitude it was necessary to select names from those already proposed, or to get rid of confusion by giving new ones. Agassiz's names, *altus*, *emarginatus*, &c., are too descriptive, and would prove misleading if used for the new aggregate. It would also promote confusion to select at

[1] Agassiz speaks of more than one example in the cases of *altus* and *planus* alone.

[2] Supra, p. 21; Miall, 'Palæontologia Indica' (1877).

[3] Supra, p. 26.

random one out of this long list, and extend its signification so as to include under it all the rest. I might, however, have adopted Agassiz's little-descriptive name *dædaleus*, had the type been discoverable. The figure[1] leaves room for a doubt respecting the specific identity of this form with the rest, though the probabilities are much against its distinctness. I have at length decided to give to the new species, under which most of those named by Agassiz are now placed, the name *polymorphus*, which Sir Philip Egerton suggests as appropriate to so variable a series. For the second species Agassiz's name *parvus* may be retained, though the figure[2] is not very distinctive.[3]

While advocating the use of these two specific names, I think it must be admitted that no species of fishes can be regarded as well established, so long as they rest upon fossil teeth alone, and this distrust is naturally increased when the fossil teeth are, as in the present case, remarkably variable. Indications are not entirely wanting of a bridge between *parvus* and *polymorphus* (Pl. V, figs. 5, 9; Pl. IV, fig. 10), and it will be wise to accept such determinations as liable to be upset altogether by future additions to our collections.

C. POLYMORPHUS, n. sp. Pl. II, figs. 1—13; Pl. III, figs. 1 *a*, *b*, *c*, 2, 5 *a*, *b*, *c*; Pl. IV, figs. 1—11; Pl. V, figs. 1 *a*, *b*, 5.

Large; variable in form, ranging from triangular to oval; opposed surfaces generally sinuous, sometimes flat, the mandibular tooth more often concave, if each is simply curved; usually strongly pitted. Denticles generally 5—4, the first often prominent, especially in the palatal tooth; the ridges from the denticles low and ill-defined, not reaching the angle. External margin sinuous, not angulated, usually defined. Thickness variable, probably according to age; in presumed young specimens the denticles less prominent.

Pl. II, figs. 5, 10, 11, 13 (mandibular), and Pl. IV, figs. 1, 9, Pl. V, fig. 1 (palatal), are extreme forms, but connected with such more ordinary teeth as Pl. II, figs. 2, 3, 4, 6 (mandibular), Pl. III, fig. 5, Pl. IV, fig. 3 (palatal), by many gradations. Pl. III, fig. 1, connects this species with *C. runcinatus*, Plieninger.

It must not be forgotten that the teeth furnish the only specific characters of the fossil *Ceratodontes*, and that these are highly special as to number, size, and form. It may well be that they varied more conspicuously than other parts of the body, like the

[1] 'Poissons Fossiles,' t. iii, pl. xx, fig. 16.

[2] Ibid., fig. 1.

[3] It is satisfactory to know that the great reduction of species here proposed has the general approval of Mr. E. B. Tawney, the custodian of the Bristol fossils, who has long held that the Protean Ceratodonts of Aust Cliff were reducible to a very few variable species. I have to thank Mr. Tawney for valuable suggestions, as well as for much friendly help in studying, describing, and figuring the collection under his care.

horns of some *Cervidæ*, the tusks of Elephants, or the opercular valves of *Pyrgoma*. Mr. Darwin attributes to Mr. Waterhouse the saying that "a part developed in an extraordinary degree or manner, in comparison with the same part in allied species, tends to be highly variable."[1] This maxim would apply well to *Ceratodus*.

The variability of the teeth is perhaps in part due to difference in their setting. This is suggested by the circumstance that the signs of wear affect various parts of the teeth in different cases. Sometimes the whole exposed surface is abraded; sometimes only the tips of the denticles; often the tips of the denticles and the internal angle. Many are worn along the vertical inner margin, while in a few the abraded surface looks quite away from the usual grinding-plane. The flat, regular, triangular forms (Pl. II, figs. 2, 3, 4, 11, 12, 13, Pl. IV, figs. 7, 10), were probably set horizontally; the irregular oval teeth with prominent denticles (Pl. II, figs. 6, 7; Pl. III, fig. 1; Pl. IV, figs. 1, 2, 4, 5, 6; Pl. V, fig. 1), may be supposed to have been inclined so as to present the inner edge more readily than the other to the opposed tooth.

I cannot distinguish Quenstedt's *C. cloacinus*[2] (Lias-kloake of Tübingen) from this species, but a larger suite of examples is needed to pronounce them identical. The teeth from the German Trias seem distinct. *C. Gulielmi*, Plieninger,[3] is perhaps the nearest, but not very near. *C. Kaupii*, Agassiz, is more palmate, the ridges more produced, and the internal border elevated much beyond what is usual in our species.[4] Of the species from Malédi, provisionally named by Dr. Oldham,[5] *C. Virapa* reminds us of *polymorphus*, but has the ridges longer, more elevated, and more regular. I consider it distinct, but allied, perhaps more nearly than is the second species found at Aust. The general form, elongate with nearly parallel sides, would be exceptional, though not unexampled, in *polymorphus*.

Formation.—Rhætic.

Locality.—Aust Cliff, on the Severn.

Reference.—Agassiz, P. F., vol. iii, pp. 131—135.

C. PARVUS, Ag. Pl. V, figs. 3 *a*, *b*, 4 *a*, *b*, 6—10.

Smaller and more constant than *polymorphus*. Triangular, with the internal angle usually well-defined, opposite to the second denticle, or nearly so. Denticles generally 5—4; ridges prominent, often extending to near the angle. External margin deeply sinuous, usually ill-defined.

[1] 'Origin of Species,' 5th ed., p. 185.

[2] 'Der Jura,' p. 34, pl. ii, fig. 128.

[3] 'Paläontologie Wurttembergs,' p. 78, pl. x, fig. 13.

[4] The figure in the 'Poissons Fossiles,' t. iii, pl. xviii, fig. 4, shows what is apparently a slip of bone attached behind the second denticle, and directed backwards, as in the recent *Ceratodus*.

[5] 'Mem. Geol. Survey of India,' vol. i, p. 295 (1859).

The above definition includes all the characters common to this species, but distinctive from some other, which I have been able to discover. Pl. V, figs. 4, 10, may be taken as fairly typical examples. Figs. 5, 9, though at first sight similar to the other two, seem to me to run into *polymorphus*. Hence arises some hesitation as to the distinctness of the present species, which I nevertheless retain until the case is clear. *C. parvus* is not altogether unlike what Agassiz calls *C. Phillipsii*, from the Oolite of Stonesfield, but it would be idle to attempt to identify or distinguish that species from the figure,[1] or from the single tooth of *Ceratodus* from Stonesfield now in the British Museum. *C. serratus*, from the Keuper of Argovie,[2] resembles it in its prominent ridges, small size and well-defined internal angle. It would be interesting to know more of this species, and in particular whether the six denticles are normally present in the teeth of either jaw. *Serratus*, to judge from the single tooth figured, has the ridges longer and more convergent than *parvus*. In the collection from Malédi, made by the Geological Survey of India, are two teeth which remind us of *C. parvus* (Pl. V, figs. 11, 12). They bear much the same relation to *C. Hislopianus* which *parvus* does to *polymorphus*, or *serratus* to *Kaupii*. The occurrence in India, Germany, and England of two sets of fossil teeth—a larger form in each case, with less defined ridges and internal angle, and a smaller, with apparently a more regular outline, defined ridges and a tolerably constant internal angle—suggests that we may have to deal with two states of growth, of perhaps three nearly allied species. I have considered this view, but cannot as yet accept it. It must be established, if it should ever be established at all, by the production of more numerous connecting states than are as yet known to exist.

Formation.—Rhætic.

Locality.—Aust Cliff, on the Severn.

Reference.—Agassiz, 'Poissons Fossiles,' vol. iii, p. 132.

[C. OBTUSUS, *Ag.*]

Agassiz describes the single imperfect tooth known in these terms:

"It is easy to distinguish this species of teeth from the preceding. Its surface is flat and perfectly smooth; the blunt denticles do not project above the surface of the crown; they are merely separated by depressions merging into the notches of the external margin. The anterior [posterior] denticle is smaller than the three succeeding ones, which are slightly inclined forwards [backwards]; the last [first], which is not larger than the lateral denticles, is itself transverse. The internal margin is irregular. While the surface of this tooth is in general flat, its posterior [anterior] margin is much raised above the anterior [posterior], which falls gradually, as fig. 20 shows."

[1] 'Poissons Fossiles,' atlas, t. iii, pl. xix, fig. 17.

[2] Ib., t. iii atlas, t. iii, pl. xix, fig. 18.

The original, from the Rhætic of Aust Cliff, is now in the Cabinet of the Earl of Enniskillen, whom I have to thank not only for the opportunity of studying this fossil, but for invaluable help of all kinds in the preparation of the present memoir. I regret that I cannot as yet accept Agassiz's decision as to the specific distinctness of *C. obtusus*, supported as it is by opinions no less worthy of respect. After tracing the remarkable variations of *C. polymorphus*, I should be slow to rank *obtusus* as specifically distinct. Still, it cannot be exactly paralleled by any tooth known elsewhere, nor can its gradation into *polymorphus* be clearly made out as yet. I propose to leave it as a questionable species, waiting for a well-founded decision as to its true place.

[C. DISAURIS, *Ag.*]

Another form, even more aberrant than *C. obtusus*, is the single specimen of *C. disauris* (*C. bicornis* of Agassiz's plate). Here, again, I quote the original description:

"This is the most singular species of the genus; it ought even to form a separate group, so much does it differ from its congeners, at least in form.

"This tooth is also derived from the Lias [Rhætic] of Aust Cliff, and is contained in the collection of Mr. Johnson at Bristol. What particularly distinguishes it is, that its internal margin is uniformly rounded at both ends, and that the denticles of the external margin, instead of converging regularly towards one of the angles, stand out at right angles to the side, which is itself rectilinear. The surface of the crown is very smooth and slightly uneven (bosselée)."[1]

The obvious difference between this tooth and that of any other known to us does not seem to me to carry the whole question. Equally strange eccentricities affect the dentition of individual hares and camels, and every person with opportunities for observation must have observed distorted teeth in the Salmon and other common fishes. The difference in form between *C. disauris* and *C. parvus* or *serratus* is so extreme, and as one may perhaps say, so purposeless, that I prefer to treat it as an individual and not as a specific trait, due possibly to injury repaired during life. Were the two central denticles of *serratus* crushed in an early stage of growth and never properly renewed, the resulting tooth would be not unlike *disauris*. Proof of the specific character of the peculiarities of the supposed species can, as it seems to me, be afforded only by their recurrence in a constant degree.

[1] 'Poissons Fossiles,' t. iii, p. 135. The original specimen is in the cabinet of Sir P. M. de Grey Egerton at Oulton Park.

[C. Phillipsii, *Ag.*] Pl. V, figs. 13, 14.

The following is Agassiz's account:

"This is the smallest species of tooth of this genus which I know; it was communicated to me by Professor Phillips, and comes from the Oolite of Stonesfield. The internal edge is straight; the tooth is particularly distinguished by its very prominent denticles, sharply cut, much compressed, and separated by deep grooves, which extend far upon the surface of the crown, the flat part of which projects very little beyond them. The posterior [anterior] denticle is transverse, truncate at its extremity, and shorter than the lateral denticles; the anterior [posterior] denticle is a mere prolonged thickening of the internal border; the three lateral denticles are successively longer and more prominent up to the third, which is the largest of all."[1] There are shown in the figure five denticles, of which the second, counting from the front, is the largest.

Another example, of what may be the same species and from the same locality is preserved in the British Museum. The locality and formation are not authenticated.[2] It cannot be decided on the basis of these two fossils, one of which is now lost, whether the species (*Phillipsii*) is distinct, and whether both examples are referable to it. The drawings (Pl. V, figs. 13, 14) seem to differ conspicuously, but in this variable genus it is useless to reason from scanty data.

[C. lævissimus.] Pl. V, fig. 2.

Another doubtful form is *C. lævissimus*, from the Upper Keuper Sandstone of Glover's Hill cutting, Ripple, Worcestershire. The original, shown in Pl. V, fig. 2, is now in the British Museum. I cannot ascertain who is responsible for the naming of the species, which seems to be undescribed.

This appears to be the only British example from the Trias proper. It cannot be satisfactorily discussed, so long as we have only a single fragmentary specimen to deal with. It seems to me to resemble not *polymorphus* or *parvus*, but the group including *Gulielmi*, *palmatus*, and *Weissmanni* of the German Trias. These species (I cannot say how far they are separable from one another) agree with the present tooth in their considerable breadth, nearly central internal angle, obtusely sinuous external margin, and tolerably defined but blunt ridges.

[1] 'Poissons Fossiles,' t. iii, p. 135.

[2] Ante, p. 26.

PLATE I.

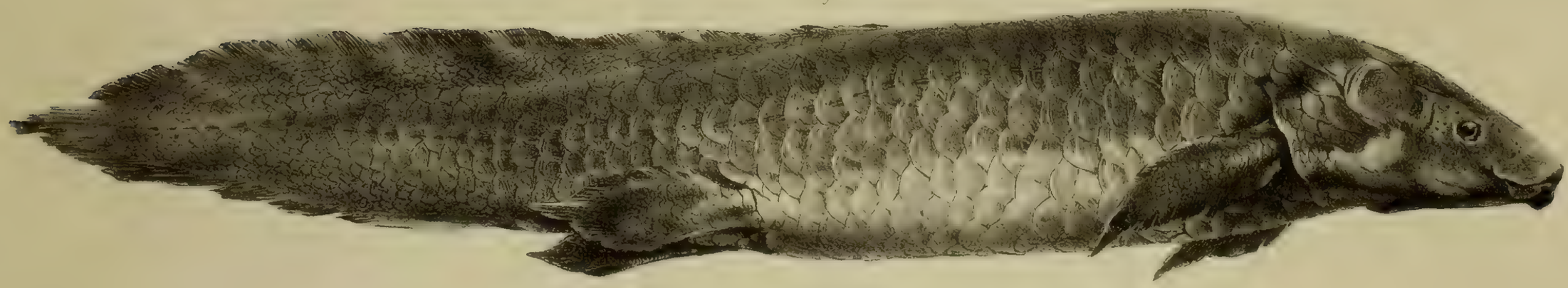
Recent Sirenoidei.

Fig.

1. *Protopterus annectens,* Ow. Reduced from specimen in the British Museum.
2. *Ceratodus Forsteri,* Krefft. Reduced from specimen in the British Museum.

Fig 1

Fig 2



A Parsons lith

Hanhart imp

PLATE I A.

Recent Sirenoidei.

Fig.

1. Skull of *Protopterus annectens*, Ow.
   - *Na.* Nasal.
   - *Pt. pal.* Pterygo-palatal.
   - *Qu.* Quadrate.
   - *E. O.* Ex-occipital.
   - *Op.* Opercular.
   - *I. op.* Inter-opercular.
   - *D.* Dentary.
   - *Ang.* Angular.
   - *Hy.* Hyoid.
2. Skull of *Ceratodus Forsteri*, Krefft.
   - *Pt. O.* Post-orbital.
   - *Sq.* Squamosal.
3. Skull of the same. The lateral cartilages are largely removed, and the right ramus of the mandible is turned.
   - *Fr.* Frontal.
4. Pterygo-palatal of *C. Forsteri*, to show the process for union with the frontal.

Figs. 1—3 are mainly from specimens in the Museum of the College of Surgeons. All the figures are of the natural size. The blue tint indicates cartilage.

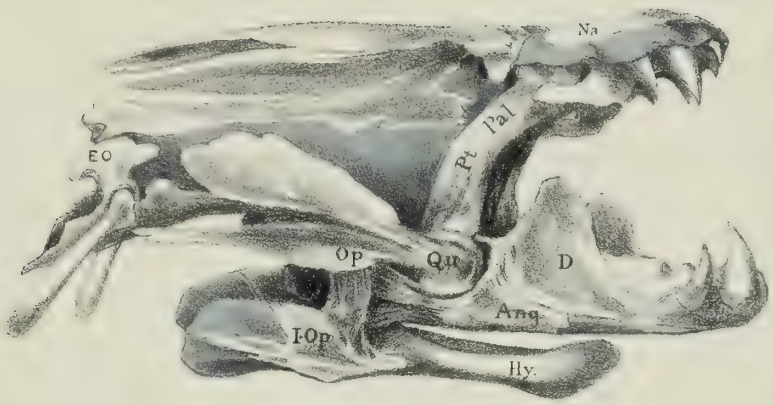


Fig 1

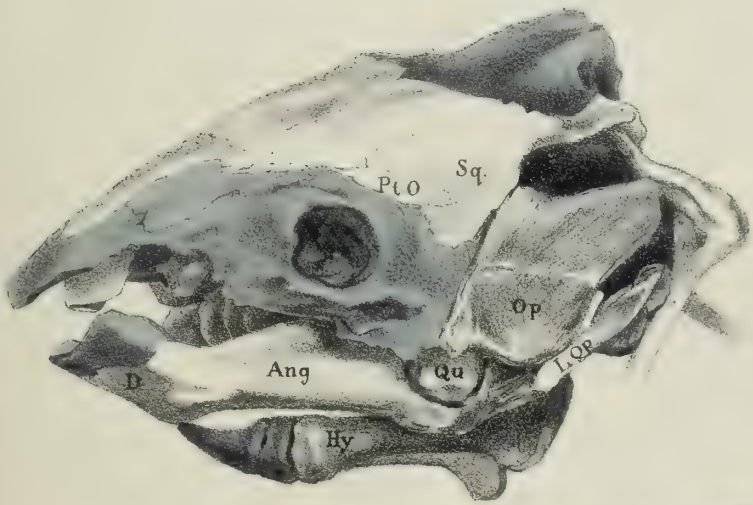


Fig 2

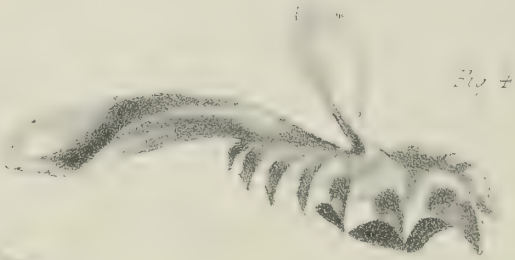


Fig 4

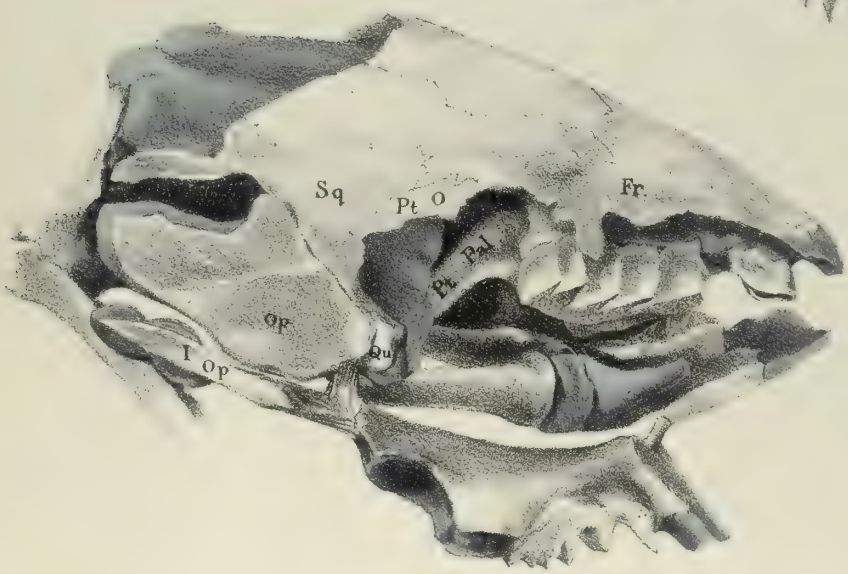


Fig 3

PLATE II.

Ceratodus polymorphus—Mandibular Teeth.

Figs.

1—13. Specimens from the Rhætic of Aust Cliff, in the Bristol Museum.

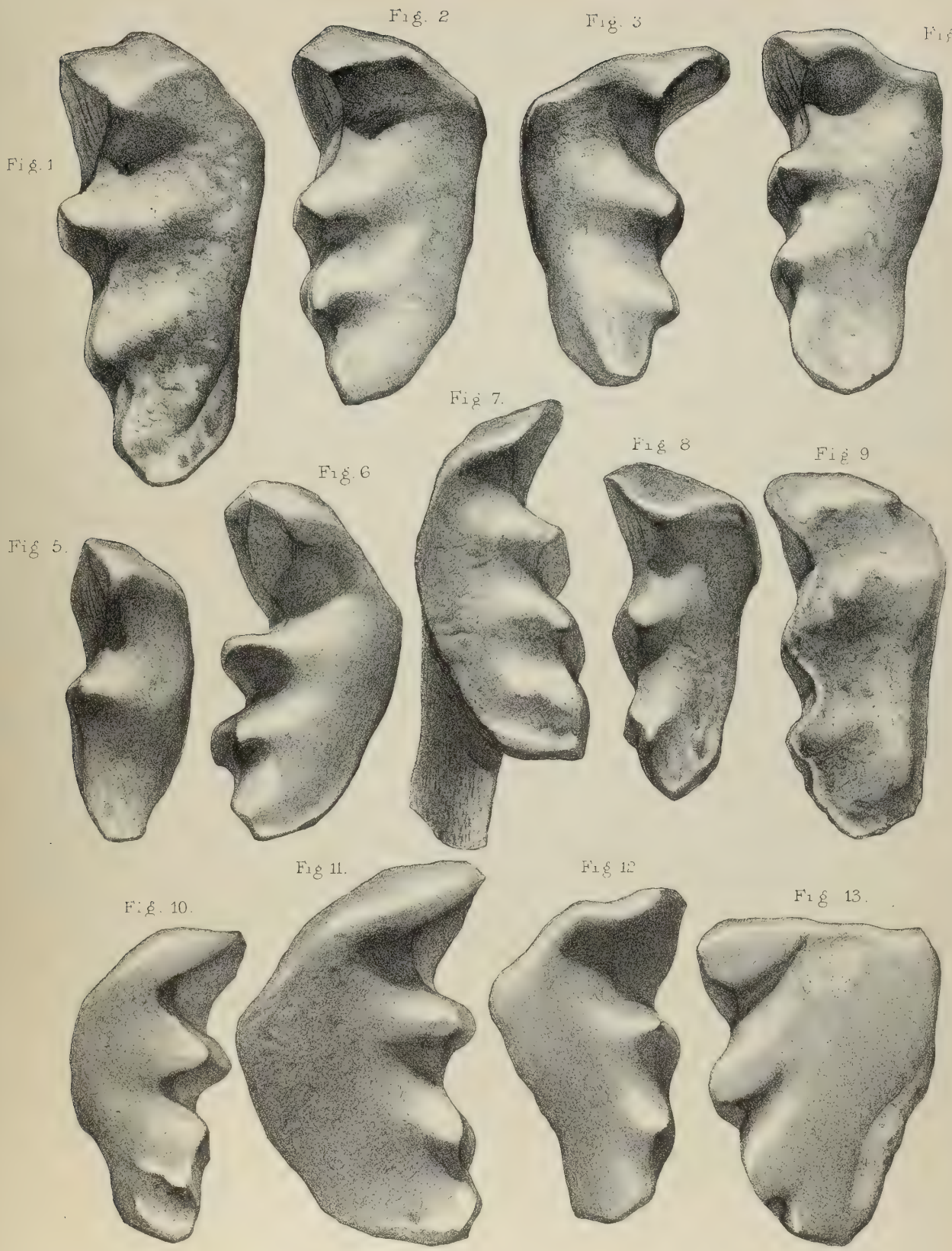
The figures illustrate the uncertain association of many characters which have been relied upon as specific, such as breadth, angulation, prominence of denticles or ridges, number of denticles, definition of external margin, &c. The following series show noteworthy gradations:

(1.) 5, 12, 3, 4, 1.

(2.) 13, 11, 10, 7, 3, 2, 1.

(3.) 13, 11, 6, 7, 3, 2, 1.

Fig. 5 has no third denticle, but this form is connected with the rest by a tooth in the Museum of Practical Geology ($X\frac{2}{5}$), and this in turn by Fig. 12 of the present Plate. Fig. 7 shows the attached splenial bone. Figs. 1, 2 have the first denticle unusually prismatic. Figs. 11 and 13 are very broad; 9 and 13 very flat. Fig. 10 has the external margin particularly defined.



H. Sykes del et lith

W. West & Co. imp

PLATE III.

Ceratodus—Mandibular and Palatal Teeth.

Fig.

1 (*a*, *b*, *c*). Mandibular tooth of *C. polymorphus*, n. sp., from Aust Cliff (Bristol Museum). The internal margin is remarkably lofty. This tooth is connected with more ordinary forms by various examples in the Bristol Museum, particularly by Nos. 158 and 159 (Higgin's Collection). The hinder part of the internal margin appears to have been broken and repaired during life. The oblique surface (x, Fig. 1 *a*) is worn flat by use.

2. Mandibular tooth and attached splenial bone of *C. polymorphus*, from Aust Cliff (Bristol Museum).

3 (*a*, *b*). Mandibular tooth and attached splenial bone of *C. Hunterianus*, Old., from Malédi, Central India. See Oldham, 'Mem. Geol. Survey of India,' vol. i, p. 295 (1859), and Miall, 'Palæontologia Indica' (1877).

4 (*a*, *b*). Mandibular tooth and attached splenial bone of *C. Gulielmi?* Copied from Schlumberger, 'Bull. Géol. Soc. de France,' 2e sér., tom. xix, pp. 707, 708, pl. xvii (1862).

5 (*a*, *b*, *c*). Palatal tooth of *C. polymorphus*, with attached pterygo-palatal bone. 5 *c* shows the root of the process for union with the frontal.

Fig. 3ª

Fig. 1ª

*

Fig. 3ᵇ

Fig. 5ª

Fig. 4ª

Fig. 4ᵇ

Fig. 2.

Fig. 1ᵇ

Fig. 5ᵇ

Fig. 1ᶜ

Fig. 5ᶜ

H. Sykes, del et lith

W West & Cº imp.

PLATE IV.

Ceratodus polymorphus—Palatal Teeth.

Figs.

1—11. Specimens from Aust Cliff (Bristol Museum).

Figs. 1, 2, 6, and 11, have the first denticle broken to such an extent as to alter the outline of the tooth. Fig. 2 is broken from x to x. Fig. 11 is probably a palatal tooth with no distinct fourth denticle. Fig. 10 should also be compared with Pl. V, figs. 5 and 9.

The following series may be noted:

(1.) 1, 3, 8, 9, 11.
(2.) 1, 5, 4.
(3.) 1, 5, 10.
(4.) 1, 2, 3, 8, 7, 11.

Fig. 1

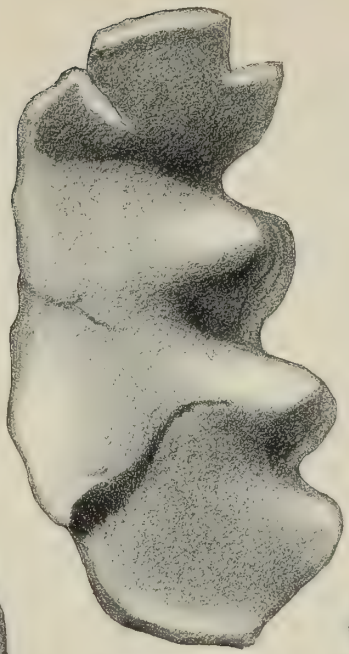


Fig 2

Fig. 3

Fig 4.

Fig 5

Fig. 6

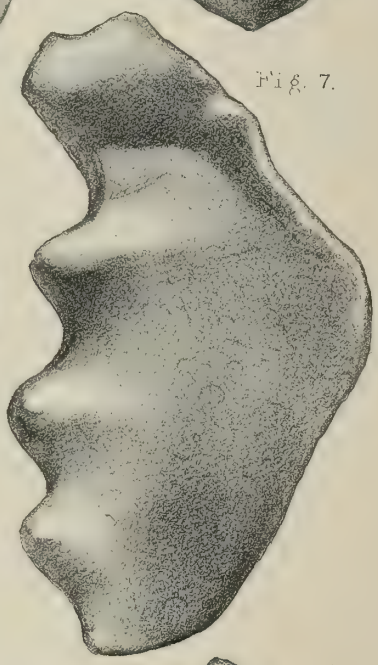


Fig. 7.

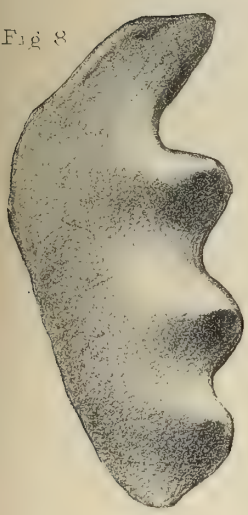


Fig 8

Fig. 9

Fig. 10

Fig. 11.

H.Sykes del et lith

W.West & Co imp.

PLATE V.

Ceratodus.

Fig.

1 (*a*, *b*). *C. polymorphus*, n. sp., palatal tooth, from Aust Cliff. (Bristol Museum.) A curiously distorted specimen, with the prominences worn flat; broken.

2. "*C. lævissimus*," palatal tooth, from Upper Keuper Sandstone of Ripple, Worcestershire. (British Museum.)

3 (*a*, *b*). *C. parvus*, Ag., mandibular tooth, with attached bone, from Aust Cliff. (British Museum.) Five denticles.

4 (*a*, *b*). *C. parvus*, palatal tooth, from Aust Cliff. (Bristol Museum.) Remarkable for the depth of the external margin and the prominence of the ridges.

5. *C. polymorphus ?*, mandibular tooth, from Aust Cliff. (Bristol Museum). A possible link between *polymorphus* and *parvus*.

6. *C. parvus*, palatal tooth, from Aust Cliff. (British Museum.)

7. *C. parvus*, mandibular tooth, from Aust Cliff. (British Museum.)

8. *C parvus ?*, from Aust Cliff. (Bristol Museum.) Both ends imperfect.

9. *C. parvus ?*, palatal tooth, from Aust Cliff. (Bristol Museum.)

10. *C. parvus*, palatal tooth, from Aust Cliff. (Bristol Museum.)

11 (*a*, *b*). *Ceratodus* (sp. ?), from Malédi, Central India, with attached splenial bone (see p. 30).

12 (*a*, *b*). *Ceratodus* (sp. ?), from Maledi, with attached pterygo-palatal (see p. 30).

13. *C. Phillipsii*, Ag. ? Stonesfield Slate ? (British Museum). (See pp. 26, 32).

14. *C. Phillipsii*. Outlined from Agassiz's figure. P. F., tom. iii, pl. xix, fig. 17.

15. *C. serratus*, Ag. Keuper of Argovie. Outlined from Agassiz's figure. P. F., tom. iii, pl. xix, fig. 18. (See p. 30, supra).

Fig.1a

Fig.1b

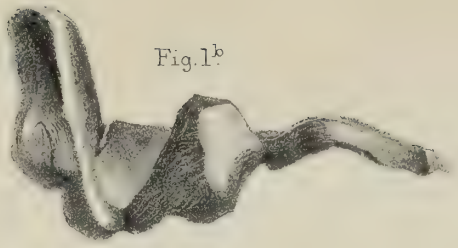


Fig.2

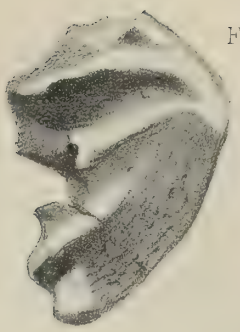


Fig.3a

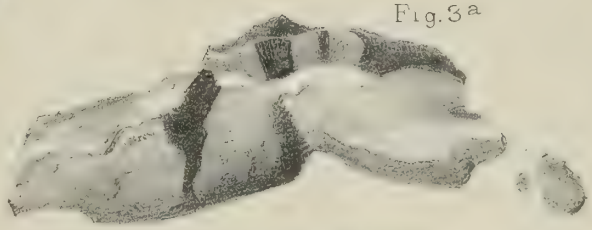


Fig.3b

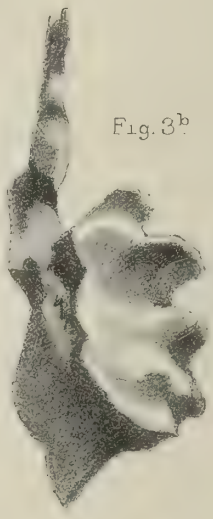


Fig.4b

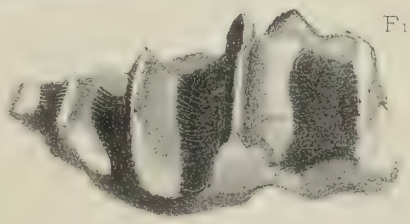


Fig.4a

Fig.6

Fig.7

Fig.8

Fig.5.

Fig.9

Fig.12a

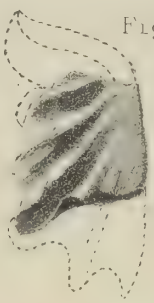


Fig.11a

Fig.10

Fig.15

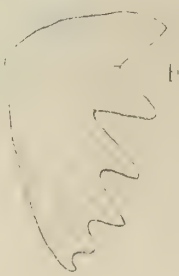


Fig.12.

Fig.14

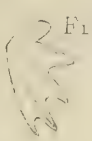


Fig.11b

Fig.12b

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MDCCCLXXVIII.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. VIII.

PAGES 1—15; PLATES I—VI.

CROCODILIA (GONIOPHOLIS, PETROSUCHUS, AND SUCHOSAURUS).

BY

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ETC. ETC.

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TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(GONIOPHOLIS, PETROSUCHUS, AND SUCHOSAURUS.)

ORDER. *CROCODILIA.*

Genus—GONIOPHOLIS, *Owen.*[1]

Species—*Goniopholis crassidens.*[2] Plates I—IV.

THE knowledge of this remarkably well-defended Amphicœlian Crocodile has been chiefly derived from a study of the specimen now in the British Museum, obtained in 1837 by ROBERT TROTTER, Esq., F.G.S., from a quarry of Purbeck stone in the vicinity of Swanage.[3] Confirmation and additional characters of the genus have been afforded by more fragmentary remains obtained by MANTELL from the Wealden of Tilgate, and by G. B. HOLMES, Esq., from the Wealden of Cuckfield and the vicinity of Horsham.

The first indication of the genus was given by detached teeth, one of which is figured in Plate I, fig. 3, from the Tilgate quarry, and which presented a more robust form of crown than that of *Suchosaurus* and other *Crocodilia*, then known, of that formation; the proportions being rather those of the teeth of the procœlian broad-faced Crocodiles[4] and Alligators[5]

[1] 'Report of the British Association,' "On British Fossil Reptiles," Part II, 1841, p. 69.

[2] Ib., ib., p. 69.

[3] A reduced view of this group of parts of the same skeleton is given in Mantell's 'Wonders of Geology,' vol. i, pl. i, 3rd edit., 1839. The quarry belongs to the 'Limestone Series' of the 'Middle Purbeck.'

[4] Cuvier, 'Ossemens Fossiles,' 4to, tome v, part ii, pl. i, figs. 4 and 5.

[5] Ib., Ib., figs. 6, 7, 8.

of the Tertiary and modern times.[1] The resemblance was carried out by the unequal size of the teeth in the same jaw, as shown by portions of *maxillæ* and *mandibulæ* subsequently acquired. But the Wealden teeth differed in the longitudinal ridges of enamel traversing the exterior of the crown; such ridges being numerous, close-set, and neatly defined. Two of the ridges, longer than the rest, traverse opposite sides of the tooth, about midway between the fore and hind outlines in the side-view. In the larger teeth (Pl. I, fig. 3) they extend from the base to the apex; in the smaller teeth (ib., figs. 4 and 6) these opposite ridges are limited to the apical half of the crown, to which they may give somewhat of a trenchant character. At the back part of the series (ib., fig. 7) the dental crown becomes obtuse, as it is shown to do in a former Monograph (tom. cit.), in *Alligator Hastingsiæ* and *Crocodilus Spenceri*.

On these characters the present genus and species were originally founded,[2] and the fortunate preservation of two teeth in the lower jaw of the dislocated parts of the skeleton from the Purbeck stone determined its generic, if not specific, affinity with the Wealden type of *Goniopholis crassidens*.

In the notable slab from Swanage the parts which first and more especially attract attention are the numerous, large, bony, dermal plates or scutes. These are scattered irregularly over the slab, and in their number and relative size bring the species much nearer to the extinct Teleosaurs than to any of the existing Crocodiles; they differ, however, from both the dorsal and ventral scutes of the Teleosaur in their more regular quadrilateral figure (Pl. IV, fig. 1); they are longer in proportion to their breadth than most of the Teleosaurian scutes, and are distinguished from those of other Crocodilians, recent and fossil, by the presence of a conical, obtuse process (ib., *a*), continued from one of the angles, transversely to the long axis of the scute: it is analogous to the peg or tooth of a tile, and fits into a depression on the under surface of the opposite angle of the adjoining scute; thus serving to bind together the plates of the imbricated bony armour, and repeating a structure which is characteristic of the large bony and enamelled scales of many extinct Ganoid Fishes. Some of the scutes in the Swanage specimen are 6 inches in length and $2\frac{1}{2}$ inches in breadth; the average length is that shown in the figure.

The exterior surface of the scute is impressed by numerous deep, round, oblong, rarely angular pits, from two to four lines in diameter, and with intervals of about two lines, defined by convex, reticularly disposed ridges of the bone; but a larger proportion of the border of the scute is overlapped by the contiguous scute than in the Teleosaur, and this part (Pl. IV, fig. 1, *c*) is smooth and thinner than the rest of the scute. The whole of the inner surface of the scute (Pl. III, *b*) is smooth; but on

[1] See "Monograph on Reptilia of the London Clay," in the volume of the Palæontographical Society, issued for the year 1849.

[2] 'Report,' loc. cit.

close inspection it is seen to be everywhere impressed by fine, straight lines, decussating each other at nearly right angles, and indicating the structure of the corium in which the scutes were imbedded. Thus, from the size and strength of these dermal bones, their degree of imbrication, and the structure for interlocking, we may conclude that the *Goniopholis* was better mailed than the Teleosaur, which Cuvier regarded as "l'espèce la mieux cuirassée de tout le genre."[1]

In the slab in question the vertebræ were all at right angles to the exposed plane, and fractured across the middle, one extremity being buried in one of the halves of the slab, and the other in the opposite half. By permission of the Trustees of the British Museum, I proceeded, in 1841, to remove the matrix from the two extremities of the same vertebra, and so demonstrated that both articular ends were equally but slightly concave (Pl. II, figs. 8, 9).

	Inches.	Lines.
The length of the body of the vertebra examined was . .	2	0
Vertical diameter of the articular extremity	1	9
Transverse diameter of the articular extremity	1	8
Ditto of middle of the body	0	11
Ditto of entire vertebra, including the transverse processes . .	10	0
Height of entire vertebra, including spinous process . . .	4	4
From the lower part of the centrum to the base of the transverse process	2	6

The suture which joins the neural arch to the centrum is conspicuous; it forms an ascending angle or curve at its middle part. In the degree in which the body of the vertebra expands to form the subconcave articular surfaces, in its smooth, non-articular surface, and in the circular transverse contour at the lower part of the centrum, *Goniopholis* resembles *Streptospondylus* more than it does *Teleosaurus*.

The diapophyses of the lumbar and anterior caudal vertebræ are long, straight, and comparatively slender; those of the sacral vertebræ are relatively thicker, and the spaces enclosed by their expanded extremities are smaller than in either the Teleosaurs or Crocodiles. The antero-posterior extent of the two sacral vertebræ is three inches two lines.

The ilium is broader than in the existing Crocodilians; the bifurcation of the proximal end of the ischium is more marked, and the iliac branch is more regularly rounded; the pubic branch is longer, more slender, and its articular end is more regularly convex; the distal or lower part of the ischium expands into a relatively broader plate. This character is still more conspicuous in the pubis, which equals the ischium in breadth, and begins to expand much nearer the proximal extremity than in the existing Crocodiles. In these modifications of the pelvis, as well as in the biconcave

[1] 'Ossemens Fossiles,' tom. v, pt. 2, p. 139.

structure of the vertebræ, the Crocodilian of the Purbeck limestone, like others of the Mesozoic epoch, was probably more marine than existing Crocodilians. The caudal vertebræ were provided with long, narrow, unanchylosed chevron bones.

The portion of the mandible preserved in the Purbeck slab belongs to that part of the left ramus included between the articular extremity, which is broken off, and the hind commencement of the dental series, of which two teeth (Pl. I, fig. 7) remain. This portion of jaw measures 1 foot 6 inches in length, and 5 inches in greatest depth. In these proportions, and the curve of the lower margin, it deviates from the Oolitic Teleosaurs and Steneosaurs, and resembles the modern Crocodiles; and although not quite equalling these in the robust proportions of the jaw, yet it much exceeds in this respect the Crocodilians with more slender teeth.

Portions of the skeleton of a *Goniopholis*, kindly submitted to my examination by G. B. Holmes, Esq., of Horsham, by whom it was discovered in a Wealden stratum at Cuckfield, Sussex, include the fore-part of the premaxillaries (Pl. I, figs. 1 and 2). This shows a semicircular anterior contour, and a single subcircular nostril (fig. 2 *n*), placed rather nearer the termination of the muzzle than in existing Crocodiles; but yet above; not terminal, as in *Teleosaurus*, nor subterminal, as in *Steneosaurus*. There is not enough of the bone preserved to show whether there was a constriction of the upper jaw behind the nostril, as in the Gavial. The incisive foramen is not immediately beneath the nostril, as in the modern and Tertiary Crocodiles. The outer surface of the premaxillaries is convex, rather irregular, with vascular foramina and wrinkled impressions. The margins of the symphysis (*s*) are a little produced. There are four alveoli in each premaxillary, as far as the bone is preserved; they are proportionately larger, more numerous, and closer together than in the corresponding part of the *Streptospondylus* or *Steneosaurus brevirostris*.[1] The first and smallest socket is in contact with the second, which is the largest; the intervals increase beyond this socket (Pl. I, fig. 1). The palatal surface shows a pair of large and deep approximate fossæ, and a second pair of smaller fossæ, apparently for lodging the crowns of the anterior teeth of the lower jaw.

The subject of fig. 5, Pl. I, is from the Purbeck stone, and of a somewhat larger individual than the Cuckfield specimen.

In a mandibular fragment from Cuckfield (Pl. I, fig. 8) the cylindrical fang of a well-preserved tooth is invested by smooth cement; the coronal ridges begin at the basal line of the enamel, and proceed nearly parallel to the apex of the cone. In a tooth with a crown one inch long and half an inch across the base four ridges are included in a space of one line's breadth; a few of the ridges are interrupted to preserve the parallelism of the rest. Towards the apex a number of shorter and finer ridges are present on each side of the two chief ridges, to which they obliquely converge. At the extreme apex of an unworn tooth the ordinary ridges terminate in fine, slightly wavy lines, forming a subreticulate surface.

[1] 'Ossem. Fossiles,' 4to, t. v, pt. 2, pl. x, fig. 6.

In the Jurassic Crocodilian (*Madrimosaurus*, V. Meyer) the coronal ridges of the teeth are more numerous, are smaller at the base of the enamel, and more of the ridges are interrupted than in *Goniopholis;* the entire tooth also seems to be shorter and thicker.

The three vertebræ represented in figs. 1—5, Pl. II, were obtained by Mr. Holmes from the same bed of Wealden clay, at Cuckfield, as the teeth and scutes, figured in Pl. III, characteristic of the genus *Goniopholis*, to which, therefore, I refer them. They correspond with the fourth, fifth, and sixth cervical vertebræ of the recent Crocodile, having a parapophysis (*p*) similar in form, extent, and position, with traces of a short and thick hypapophysis, *hy*, at the fore part of the under surface; but that surface of the Wealden vertebra is less convex, the whole centrum is relatively broader, and the more important difference of the concavity of the hinder as well as of the fore articular end manifests the distinct family of *Crocodilia* to which the *Goniopholis* belongs. The depth of the concavity of these surfaces exceeds that in *Teleosaurus*. The free surface of the centrum is smooth. The neural arch articulates with the whole length of the centrum by the neurapophysial surfaces of the form shown in fig. 5, *np*. The neural canal (ib., *n*) slightly widens behind. Two vertical, venous canals open into the neural one. Fig. 6 is the side-view of a cervical centrum from the Purbeck beds, having the general proportions of those of *Goniopholis*, but differing in the smaller size of the parapophysis. Figs. 7—9 are views of the centrum of a dorsal vertebra of the Purbeck *Goniopholis*, fig. 9 showing the texture as displayed by a vertical longitudinal section. It is compact or minutely cancellous throughout; whereas the centrums in the *Teleosaurus* exhibit a more open, reticulate texture, with a cavity near the centre; this cavity is still larger in *Poikilopleuron*.

One of the posterior caudal vertebræ of the Cuckfield specimen, after the subsidence of the diapophyses and the great reduction of the zygapophyses, shows the spinous process rising from the hinder part of the neural arch, as at *g*, Pl. III.

The coracoid (ib., *h*) differs from that of the existing Crocodiles in its greater relative breadth at the neck or part marked *h*, in the more gradual and minor expansion of its mesial end, and in the more regular convexity of its scapular border. It exhibits the same perforation near this border as in the modern Crocodiles.

The humerus associated with the remains of *Goniopholis* from the Wealden of Cuckfield has the usual Crocodilian form and sigmoid flexure. Compared with one from a *Crocodilus biporcatus*, with the same-sized cervical vertebræ, it is a somewhat thicker and stronger bone. It has a broader and thicker ulnar tuberosity, and the angle at which the process is bent down upon the shaft is less marked, more rounded off. The radial crest is a triangular, compressed ridge, but is not produced beyond four lines from the surface of the shaft; the distal part of the bone is proportionately thicker antero-posteriorly than in the modern Crocodiles, and the longitudinal, irregular ridges

at the margin of the articular surface are stronger; there is a similar ridge above the inner condyle.

The femur of the *Goniopholis* (Pl. III, *o*) is relatively longer, and is less bent than in the existing Gavial or Crocodile. The tibia (*m* and *n*, the latter bone presenting its narrrower side to view) is also both longer and thicker.

Dermal Scutes.

In the slab of Wealden stone from Cuckfield, containing the parts of the dislocated skeleton shown in Pl. III, there were imbedded, not only the long, quadrate, toothed scutes (*a*, *b*), like those in the Purbeck slab (Pl. IV, fig. 1), but a second form of scute (ib., *d*) of which no examples had been preserved in the Purbeck specimen. Of this second form detached specimens were obtained from the same formation and locality, of which one is figured in Pl. IV, figs. 2, 3, 4. These scutes are hexagonal, marked, as in the toothed kind, on the outer surface, by hemispheric, circular or subcircular pits, and on the inside by fine, linear, decussating lines, on an otherwise smooth and plane surface. They have no articulating process, but have a strongly marked sutural surface on the thick margin (ib., fig. 3), showing them to have been united together, like the neural and costal plates of the carapace, and like the elements of the plastron, in the Terrapene and Tortoise. The section (fig. 4) shows the depth of the external pits, the texture of the scute, and its level and even under surface, *d*.

From the association of hexagonal sutural scutes with the quadrate, oblong, toothed scutes in the specimen (Pl. III), it can hardly be doubted that they formed part of the same exo-skeleton, and are probably from the ventral region. Some slighly modified shapes are shown in the scutes marked *f* in Pl. III.

In the sixth part of the sixth volume of the 'Palæontographica' of H. v. Meyer, the author has described and figured part of the dermal skeleton of what he believes to have been a Saurian reptile, consisting of bony plates, for the most part hexagonal, and united by marginal sutures. These plates, however, do not present the uniformly pitted character of the external surface, as in *Goniopholis*, but here and there in the series they show a few irregular, large depressions; the more constant markings are smaller, apparently vascular foramina, and linear, usually radiated, impressions, in character more like the markings of the dermal ossifications of the Labyrinthodont Reptiles. The specimen described is from the "Dachsteinkalk," under the Winkelmaas Alpe, near Runpalding, in Bavaria, and it is referred to the *Psephoderma Alpinum*.

Species—*Goniopholis simus*, Ow. Plate V.

This species is founded upon the entire skull, *minus* the lower jaw, imbedded in the limestone of the Swanage quarry, of which skull a reduced view of the upper surface is given in Pl. V, fig. 1; and of so much of the under surface (ib., fig. 2) as could be brought to light by exploratory operation on that part of the imbedding slab.

The skull in its general shape corresponds with the broad-faced species of the Procœlian Crocodiles;[1] and in the festooned contour of the alveolar borders, with those having teeth of uneqal size, and with a crown of mainly the proportions of the teeth in the present Amphicœlian genus.

The conclusion conveyed by the latter expression is not, indeed, based upon the discovery of vertebræ in such contiguity with the present skull as to support an inference as to their having formed part of the same skeleton; but it is a probable one from the association of such vertebræ with the foregoing nearly allied species of *Goniopholis;* and such probability is strengthened by the nature of the cranial modifications by which the skull under review differs from those of the Procœlian species most nearly resembling it in shape.

The temporal vacuities (ib., fig. 1, *t*) are relatively larger than in *Crocodilus* proper, or broad-faced Procœlians, and are subquadrate in form. The palatonaris (ib., fig. 2, *n*) is not only larger, but is more advanced in position, so as to come wholly into view on the bony palate, and on the same plane therewith; and here, moreover, they receive for completion of their anterior contour, the hinder ends of the proper palatine bones (ib., ib. 20), three fourths only of the border being contributed by the pterygoids (ib., ib., 24). The Eustachian aperture (ib., ib., *e*) is likewise on the palatal, not the occipital, plane.[2]

In these characters is manifested the nearer affinity of the Purbeck Crocodilian to the Amphicœlian Teleosaurs[3] than any Tertiary or modern genus presents.

The following are amongst the modifications of minor import in the skull of the present species of *Goniopholis*. The external nostril (Pl. V, fig. 1, *n*), horizontal in position, is more nearly terminal than in modern Crocodiles, or than in *Goniopholis crassidens* (Pl. I, fig. 2, *n*). It is formed by the premaxillaries exclusively; the nasal bones terminating about an inch behind the nostril. In Procœlian Crocodiles a graduated series of developments of the nasal bones may be traced. They may be short, as in *Gavialis gangeticus*, or extend to near the nostril, as in *Crocodilus cataphractus*, rather nearer in *Crocodilus intermedius*, still nearer in *Crocodilus Hastingsiæ*, be produced close

[1] Cuvier, 'Ossem. Foss.,' tom. cit.

[2] 'Phil. Trans.,' MDCCCL, pl. xi, fig. 1 *e*.

[3] Ib., p. 522.

to the aperture as in *Crocodilus champsoïdes*, penetrate a short way into the aperture, as in *Crocodilus suchus*, or, by continuous ossification of the septum in old individuals of *Crocodilus niger* and *Alligator lucius*, extend seemingly across the nostril. These characters, barely of specific value, have been used in the fabrication of genera of existing Crocodiles and Alligators,[1] in all of which the orbits are larger than the upper temporal apertures.

In *Goniopholis simus* the orbits (Pl. V, fig. 1, *o*) are rather smaller than the apertures (ib., ib., *t*).

Each pterygoid(fig. 2, 24,) articulating by a crenate suture with the narrow hind end of the palatine (ib., 20), which diverges from its fellow to form the fore part of the palatonaris, loses vertical thickness and gains in breadth as it extends backward. It there articulates by a tract of an inch in length with the basisphenoid. The Eustachian canal (ib., *e*) opens at the midspace between the basisphenoid and basioccipital. The latter arches down in advance of the condyle, and the venous foramen is conspicuous on this tract.

As the pterygoids are relatively less than in the Procœlians, so the palatines are relatively larger, especially in anterior breadth. After contributing their share to the palatonaris, they come into contact and the medial suture is continued forward to an extent of 3 inches 5 lines. The anterior breadth of the pair is 3 inches 4 lines. The medial suture of the palatal plates of the maxillaries was traced forward two inches or more in advance of the palatines, and laterally the plates were exposed to the same breadth as the palatines proper. The palato-maxillary suture, $20'$—$21'$, is strongly sigmoid, describing as it leaves the midline a convexity forward and then a concavity. It was not thought expedient to endanger the unique specimen by further excavation in reference to the comparatively unimportant premaxillo-maxillary palatal suture.

The bony palate, as far as it was exposed, is smooth; the upper surface of the skull is rugose and pitted. The pits are circular or subcircular, from 1 to $2\frac{1}{2}$ lines in diameter, situated chiefly on the swollen sides of the maxillaries and on the cranial part of the skull, including the expanded upper and outer surface of the squamosals; and the tympanic pedicles are smooth, and terminate in the usual transversely extended concavo-convex articular surface.

The tooth called "anterior canine" is preserved, somewhat mutilated, in each premaxillary. Sockets of smaller premaxillary teeth are faintly traceable. The tooth termed "posterior canine" projects from the anterior part of the outswollen and convex border of the maxillary. From portions or traces of the other teeth or sockets I estimate that there were from sixteen to eighteen teeth on each side of the upper jaw. In the largest and least mutilated crowns of these teeth the dental characters of the genus *Goniopholis* are shown.

In the 'Catalogue of the Osteological Series, Mus. Coll. Surgeons,' 4to, 1853, p. 164, is described the specimen No. 752, as "The skull of a Crocodile from Bengal,

[1] 'Trans. Zool. Soc.,' vol. vi, p. 125.

wanting the lower jaw, of a species (*Crocodilus palustris ?*) which is frequently found inhabiting the larger ponds. It differs from the *Cr. biporcatus* of the Ganges in having shorter maxillary and premaxillary bones in proportion to its length, and in having much less developed prefrontal ridges; the palatal suture between the maxillary and premaxillary bones is transverse, not curved. The anterior extremities of the palatine bones are narrower and more pointed. The number of alveoli is—premaxillary 5—5, maxillary 14—14."

The doubt indicated (?) arose from the inadequate characterisation by Lesson, of the species described by him in the 'Zoologie' of the 'Voyage aux Indes Orientales de Bélanger;' but there is no reference of the specimen, No. 752, to the *Crocodilus rhombifer*, as is affirmed by the author of the "Synopsis of the Species of Recent Crocodiles," 'Trans. Zool. Soc.,' vol. vi, p. 140. I did not regard my doubt as justifying the sinking of Lesson's "*palustris*" into a synonym, and of imposing a new specific, much less generic name. But the osteological character of the palatal region of the skull, pointed out in my 'Catalogue,' appears to be the chief of those relied upon by the author of that 'Synopsis' for his genus *Bombifrons*, of which the first character is:—"The premaxillary suture straight, or rather convex forwards" (loc. cit., p. 139). The other characters are not of specific value.

The sutures of the premaxillary bones, I may remark, are of three kinds; one is medial and unites the pair; it is the "interpremaxillary suture:" the second is lateral, uniting the outer or dental plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary suture:" the third is transverse, more or less, and unites the palatal plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary palatal suture." Its modifications, added to other differences, when determined to be constant, may aid in differentiating the species of *Crocodilus* proper, of *Alligator*, and of *Gavialis*.[1]

The convenience of these three genera of Procœlian *Crocodilia*, although they agree in palatonarial and vertebral characters, will probably ensure their retention; but *Tomistoma*, *Oopholis*, *Halcrosia*, *Palæosuchus*, *Rhynchosuchus*, *Ramphostoma*, *Mecistops*, *Bombifrons*, *Palinia*, *Molinia*, *Caiman*, *Jacare*, &c., into which they have been subdivided, exemplify the evil of "encumbering the science with a multitude of names" (loc. cit.,

[1] Prof. Marsh, in his 'Introduction and Succession of Vertebrate Life in America,' 8vo, 1877, writes (p. 21):

"The beds of the Rocky-Mountain Wealden have just furnished us with a genuine "missing link," a Saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias."

When the cranial characters of this Crocodilian are made known it will be of moment to compare the temporal apertures on the upper surface and the palato-narial apertures on the under surface of the skull. When the dental characters of the same fossil are described and figured we may be able to determine whether they are those of the broad-faced procœlian Crocodiles and Alligators or those of *Goniopholis*.

p. 128),—an evil which, if the "names" do not represent "generic distinctions," cannot be laid to the charge of the "Palæontologist."

At least, the "small fragments of the fossil skeleton" (ib., p. 128) on which the genus *Goniopholis* was originally founded have subsequently been proved, by acquisition of other parts, to have indicated accurately that well-marked and interesting addition to the recorded modifications of the Crocodilian type. Those of the vertebral and cranial structures have, indeed, proved to be not only of generic, but of family value.

Genus—Petrosuchus, *Owen*.[1]

Species—*Petrosuchus levidens*. Plate VI.

This genus and species of Crocodile is founded on the portion of skull and mandible, figured in Plate VI. The skull is imbedded in the same limestone of the Middle Purbecks, now quarried at Swanage. It was discovered in a block with the upper surface (ib., fig. 1) exposed. This surface is partially weathered, but shows here and there a faintly wrinkled natural sculpturing. The upper temporal apertures are larger than the orbits. In front of these the skull contracts more rapidly than in *Goniopholis*, and presents, as far as it is preserved, a slender form of face approaching to the proportions of that in the modern *Crocodilus cataphractus*,[2] and in the Tertiary *Crocodilus champsoïdes*;[3] but the more rapid contraction in front of the orbits is gavial-like, and there are other characters indicative of a nearer affinity than in *Goniopholis* to the Teleosaurian group. This affinity is decisively marked by the larger relative size and more advanced position of the palatonaris (ib., fig. 2, *n*), into the formation of which the diverging hind ends of the palatines (ib., fig. 2, 20) enter in a larger proportion than in *Goniopholis*. The basisphenoid (ib., ib., 5) is more produced, and the pterygoid (ib., ib., 24) contracts a more extensive sutural union therewith. Each palatine bone (ib., ib., 20), where they diverge at the palatonaris, shows a protuberance on its under surface. The Eustachian outlet is seen at *e*.

The portion of the left mandibular ramus (Pl. VI, fig. 3) includes the dentary element (32), nine inches in length, with portions of the angular (30) and surangular (29); that of the angular including six inches of its extent. Of this element two inches extend forward in advance of the hindmost point of the dentary; and, guided by the proportions of the *Crocodilus champsoïdes*, I estimate the total length of the

[1] Gr. πέτρος, rock, and Σοῦχος, an Egyptian name of the Crocodile.

[2] Cuvier, 'Ossem. Foss.,' 4to, tom. v, part ii, pl. v, figs. 1 and 2; Gray, 'Trans. Zool. Soc.,' vol. vi, pl. xxxii, fig. 2.

[3] Pal. vol. for the year 1849, 'Fossil Reptilia of the London Clay,' t. iii.

mandible of *Petrosuchus levidens* to be 16 inches, or thereabouts, indicating that from four to five inches are wanting at the fore part of the subject of fig. 1.

The vertical extent of the ramus behind the mandibular vacuity (ib., fig. 3, *v*) is 1 inch 9 lines; the vacuity itself is 1 inch 6 lines in long diameter, 6 lines in short diameter; its long axis is nearly parallel with that of the ramus. The lower, like the upper jaw, appears to have been long exposed on its imbedding block of stone. Little of the outer layer of the bone is preserved, and this is limited to parts of the angular and surangular. It here shows a more decided reticulate sculpture, the meshes being in the form of subcircular pits of from 1 to 2 lines in diameter.

The vertical breadth of the dentary at the terminal point of the angular is 1 inch 3 lines; it loses, as usual, in this diameter as it advances, but irregularly, owing to a gentle undulation of the alveolar border. This is convex where it supports the anterior group of teeth opposed to the premaxillary and foremost upper canine teeth; it is then slightly concave to the mid-third part, where the border is more feebly convex; beyond this, after a feeble concavity, it gradually rises to the surangular piece (29).

Of the foremost group of teeth seven are preserved; the third counting from the foremost being the longest and broadest, with the crown curving upward and a little backward; the length of this tooth is 1 inch 4 lines, its extreme breadth is 3 lines, about half of the total length forms the exserted crown, but the point is not entire. The first and fifth of this series are the next in size, but do not exceed an inch in length, the intermediate teeth are smaller; two or three sockets of still smaller teeth may be traced in the concave part of the border. In the following convex part, seven teeth are preserved, with shorter and relatively thicker crowns than in the foremost group; but none of them showing the robust proportions of the teeth of *Goniopholis*. Behind this group the indications of teeth and sockets are faint. I estimate the number of teeth in the present ramus at about twenty; which is the number in the mandibular ramus of *Crocodilus champsoïdes:* a margin of two or three more or less being allowed for a perpetually changing set of teeth.

The inequality of the size of the teeth and concomitant festooned course of their alveolar series is Crocodilian, as contrasted with the Gavialian and Teleosaurian types. But the temporal and palatonarial openings indicate the generic distinction of *Petrosuchus*, with its transitional character between the Teleosaurian and Tertiary Crocodiles.

Portions of dermal scutes, with the pitting as on the mandible, but with wider intervals, are preserved on the slab in which the above-described fossil is imbedded.

Genus—Suchosaurus, *Owen*.[1] Suchosaurus cultridens[2] (Pl. IV, figs. 5—8).

In the Wealden formations have been found detached teeth and vertebræ, indicating the existence, at that period, of a large Amphicœlian Crocodile specifically and generically distinct from both *Goniopholis* and *Petrosuchus;* for, since the discovery of associated bones and teeth of the former genus has made us acquainted with its vertebral characters, an exhaustive analysis of the other reptilian fossils of the Wealden series leave only the form of Saurian tooth, Pl. IV, figs. 5 and 6, wherewith to associate the equally peculiar form of Saurian vertebra, ib., figs. 7, 8. This vertebra is readily distinguishable, by the length of the centrum and the compressed wedge-shaped character of its middle part, from all other known Saurian (Dinosaurian or Crocodilian) vertebræ of the Wealden period. The specimen (No. $\frac{138}{2138}$, Mantellian Collection of Wealden fossils in the British Museum) is the centrum of a dorsal vertebra, with both articular extremities slightly and equally concave; though narrower at the middle than at the ends, it is more uniformly compressed than in other Crocodilian vertebræ, the sides converging to an inferior obtuse ridge, which is very slightly concave in the antero-posterior direction. The sides are not flat in the vertical direction nor slightly concave, as in many of the Iguanodon's vertebræ, to which the present form approximates; but are gently convex, so that a pencil laid vertically upon the sides touches it only by its middle. A more decided difference between the present Crocodilian vertebræ and those of the Iguanodon is, that the former are longer in proportion to their height and depth. The external surface at the middle of the body of the vertebra is very finely striated, so as to present a silky appearance; near the margins it is sculptured by coarse, longitudinal grooves and ridges.

The base of the neurapophysis which, when anchylosed, leaves an evident trace of the suture, is nearly equal in length with the body of the vertebra; it does not wholly include the neural canal, but leaves the impression of the lower third of that canal upon the upper surface of the centrum. On the outside of the neurapophysis are two slightly developed, broad, obtuse ridges, converging towards each other from the outer side of each angle or end of the base of neurapophysis; the ridge corresponding with the posterior of these in the Iguanodon's vertebra rises more vertically, and is in higher relief. The neurapophysial suture slightly undulates in its horizontal course, and rises in the middle instead of descending upon the centrum, as in the Plesiosaurs.

The present vertebra is alluded to at p. 70, and figured at pl. ix, fig. 11, of Mantell's

[1] 'Report,' ut supra, p. 67 (Gr. Σοῦχος, an Egyptian name of the Crocodile, and σαῦρος, lizard).
[2] Ib., ib.

'Illustrations of the Geology of Sussex,' 1827, as a lumbar vertebra of the *Megalosaurus*. But in the 'Geology of the South-east of England,' the same author, speaking of this vertebra, observes, "It cannot, I now think, be separated from those figured in the same plate as belonging to a Crocodile;" p. 297, *note*. The body of the Megalosaurian vertebra has a pretty deep, longitudinal depression between the neurapophysial suture, wanting in the Tilgate vertebra here described. This, however, is not the only distinction; below the depression the centrum of the Megalosaur swells out, and is as convex below as it is laterally in the transverse section, so that the outline of a transverse section would describe five sixths of a circle; a similar section of the vertebra of *Suchosaurus* would be triangular, with the apex rounded off. The Megalosaurian vertebra is more contracted at the middle, and swells out near the articular ends, surrounding those articulations with a thick convex border; in *Suchosaurus* the lateral meet the marginal surfaces at a somewhat acute angle; but the silky striated surface of the Suchosaurian vertebra, and the smooth and polished surface of the Megalosaurian one, would effectually serve to distinguish even fragments from the middle of the body of each.

The following are dimensions of the vertebra of the large Wealden Crocodilian above described:

	No. 138.	
	Inches.	Lines.
Antero-posterior diameter of the body	3	10
Vertical diameter of its articular end	3	2
Transverse diameter of its articular end	2	9
Transverse diameter of the middle of the body	2	0

The fossil teeth from the Wealden (Pl. IV, figs. 5, 6), which I provisionally associate with the foregoing vertebra, approach by their more slender and acuminate form to the character of those of the Gavial, but differ from the teeth of any of the recent species of that genus of Crocodilians, as well as from those of the long and slender-snouted extinct genera (*Teleosaurus*, *Steneosaurus*, &c.). The crown is laterally compressed, subincurved, with two opposite trenchant edges, one forming the concave, the other the convex, outline of the tooth. In the Gavial the flattening of the crown and the situation of the trenchant edges are the reverse, the compression being from before backwards, and the edges being lateral.[1] The tooth of the Suchosaur thus resembles in form that of the Megalosaur, and perhaps still more those of the Argenton Crocodile; but I have not observed any specimens of the Wealden Crocodilian teeth in which the edges of the crown were serrated, as in both the reptiles just cited. The teeth of the Suchosaur also present a character which does not exist in the teeth of the Megalosaur, and is not

[1] The tooth attributed by M. Deslongchamps ('Mémoires de la Société Linnéenne de Normandie,' vol. vi, p. 39) to the *Poikilopleuron* agrees in form with those of the Gavial, and differs in the characters cited in the text from those of the *Suchosaurus*.

attributed by Cuvier[1] to those of the *Crocodile d'Argenton*. The sides of the crown are traversed by a few longitudinal, parallel ridges, with regular intervals of about one line, in a crown of a tooth one inch and a half in length; these ridges subside before they reach the apex of the tooth, and more rapidly at the convex than at the concave side of the crown.

Hitherto these teeth have not been found so associated with any part of the skeleton of the same species as to yield unequivocally further characters of the present extinct Crocodilian. From the above-mentioned well-marked differences between these teeth and those of all other known species, I regarded the extinct Crocodile in my 'Report on British Fossil Reptiles' as forming the type of a distinct genus and species, and proposed for it the term *Suchosaurus cultridens*. It indicates a nearer affinity or transition to the Dinosaurian order than does any of the mesozoic *Crocodilia*, known by their cranial as well as by their dental, vertebral, and dermal characters.

Of those species so recognised, including the Purbeck and Wealden kinds now added, the following are common characters. A greater development, than in Tertiary Crocodiles, of the dermal bony armour, which consists, without exception, of both dorsal and ventral scutes, the scutes in each series well connected with each other, and in *Goniopholis* exceptionally so.

A less development of the osseous surface for the origin of the muscles of the mandible indicated at the upper surface of the cranium by the larger 'temporal vacuities,' and at the under surface by the smaller pterygoid plates. Horizontal plane, larger size, advanced position and palato-pterygoid formation of the palatonares.

Amphicœlian vertebræ.

These common characters of mesozoic *Crocodilia* suggest considerations of their relation to the prey of such *Crocodilia* and also to the coexistent marine reptiles of which those *Crocodilia* themselves became the prey.

Similarly, if the common characters of the tertiary and existing *Crocodilia* be summed up they become suggestive of analogous considerations.

A minor development than in mesozoic crocodiles of the dermal bony armour, consisting, with few exceptions, of the dorsal scutes only, and these relatively smaller, thinner, and less closely knitted together, may relate to the absence of the Mosasaurs, Pliosaurs, Polyptychodonts, &c., against the assaults of which the contemporary crocodiles of those Saurians required a better defensive armour.

The greater development of the osseous surface for the origin of the muscles of the mandible, indicated at the upper surface of the cranium by the smaller, or obliterated, 'temporal vacuities,' and, at the under surface, by the more expanded alæ of the pterygoids, accords with the stronger jaws and dentition, as an adaptative to seize and subdue a stronger and more resisting kind of prey than that on which the mesozoic crocodiles habitually fed.

[1] Cuvier, 'Ossem. Fossiles,' 8vo. tom. ix, p. 331.

The oblique plane, posterior position, small size, and exclusively pterygoid formation of the palatonares, together with the procœlian vertebræ, lead one to think of the contemporary coming in, with the neozoic crocodiles, of active, warm-blooded, air-breathing mammals.

But the considerations suggested by such correlations require the wholesome sifting of discussion; and I, therefore, propose to reserve them for a communication to the Geological Society of London.

I will only add that any additional evidences of the cranial characters of Purbeck Crocodiles will be gratefully received.

PLATE I.

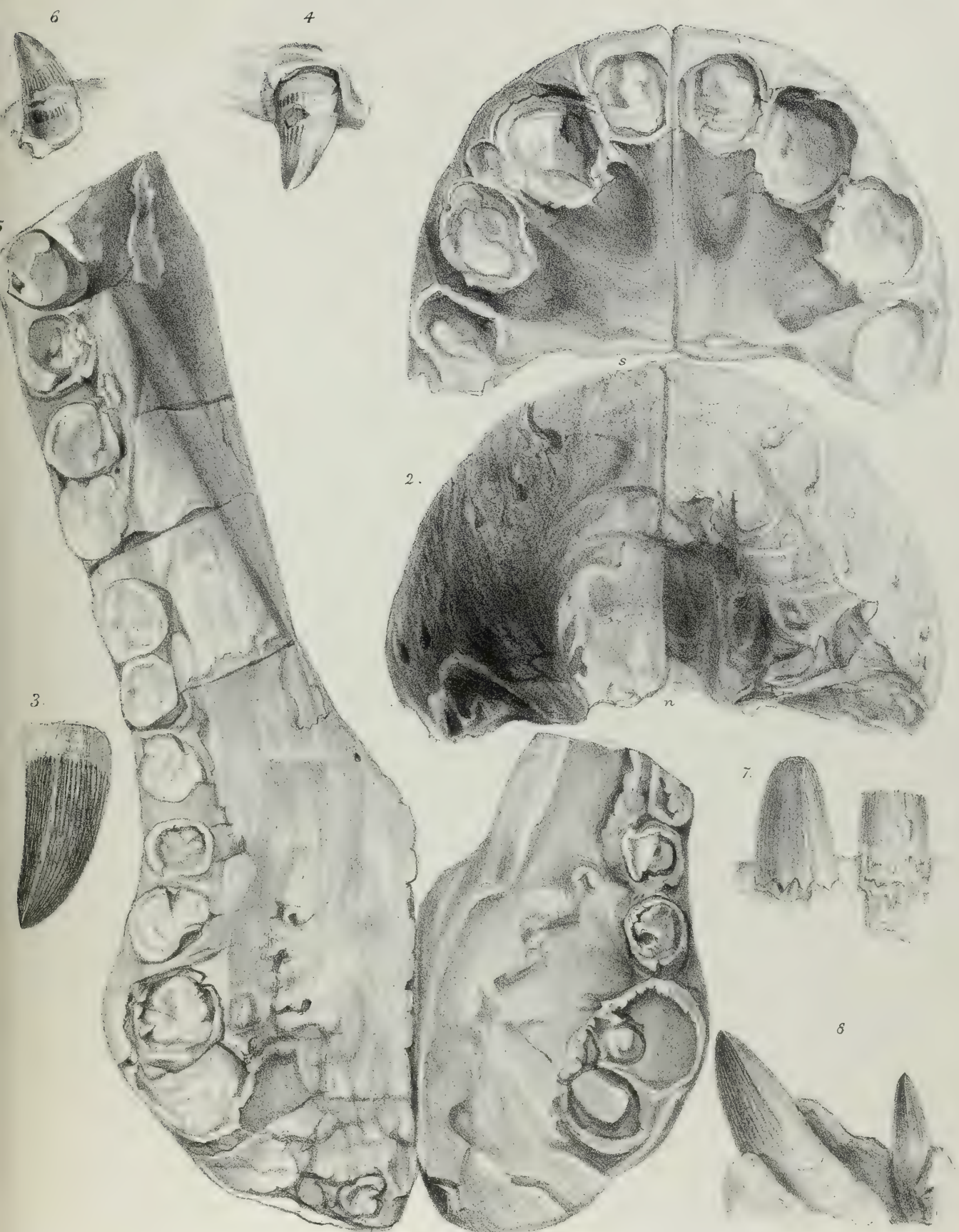
Goniopholis crassidens.

Fig.

1. Premaxillary extremity of skull, palatal surface.
2. Premaxillary extremity of skull, outer surface.
3. Crown of large maxillary tooth.
4. Crown of small maxillary tooth.
5. Symphysial extremity and part of ramus of mandible, upper or oral surface.
6. Crown of small mandibular tooth.
7. Two hindmost mandibular teeth.
8. Large and small mandibular teeth from near the middle of the series.

The subjects of figs. 1—4 are from the Wealden of Cuckfield.
The subjects of figs. 5—8 are from the Limestone Series of the Middle Purbeck.

All the figures are of the nat. size.



From nat on stone by J. Erxleben.

W. West & Co. imp.

GONIOPHOLIS CRASSIDENS.

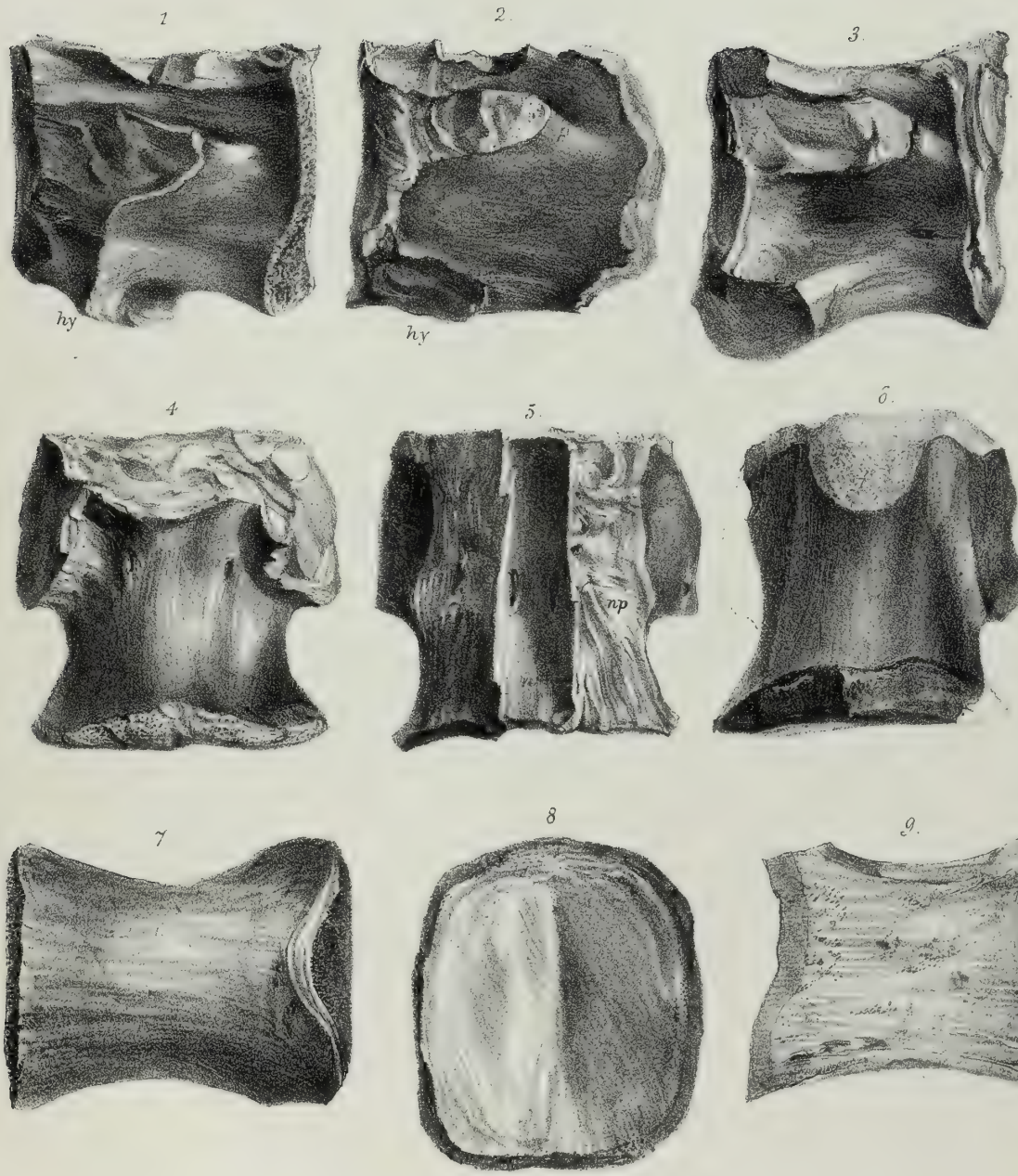
PLATE II.

Goniopholis crassidens.

Fig.

1. Side view of centrum of third cervical vertebra.
2. Side view of centrum of fourth cervical vertebra.
3. Side view of centrum of fifth cervical vertebra.
4. Under view of centrum of third cervical vertebra.
5. Upper view of the same.
6. Side view of centrum of sixth cervical vertebra.
7. Under view of centrum of dorsal vertebra.
8. Front view of centrum of dorsal vertebra.
9. Vertical longitudinal section of centrum of dorsal vertebra.

The subjects of figs. 1—6 are from the Wealden of Cuckfield.
The subjects of figs. 7—9 are from the Limestone Series of the Middle Purbeck.



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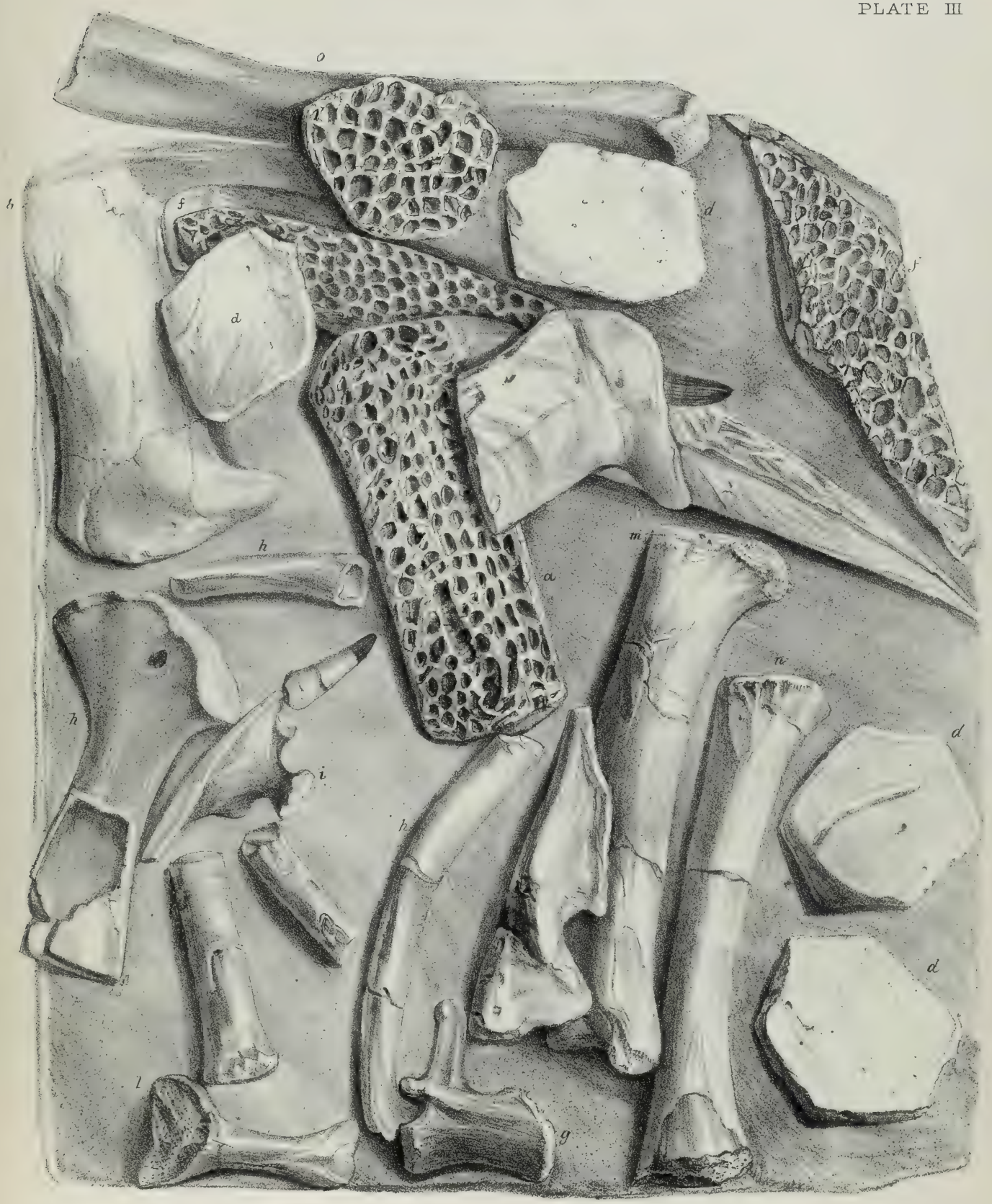
GONIOPHOLIS CRASSIDENS.

PLATE III.

Goniopholis crassidens.

A slab of Wealden Stone with bones, teeth, and scutes: two thirds nat. size.

From the Wealden of Cuckfield.



$\frac{2}{3}$

From nat. on stone by J. Endeben.

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GONIOPHOLIS CRASSIDENS.

PLATE IV.

Goniopholis crassidens.

Fig.

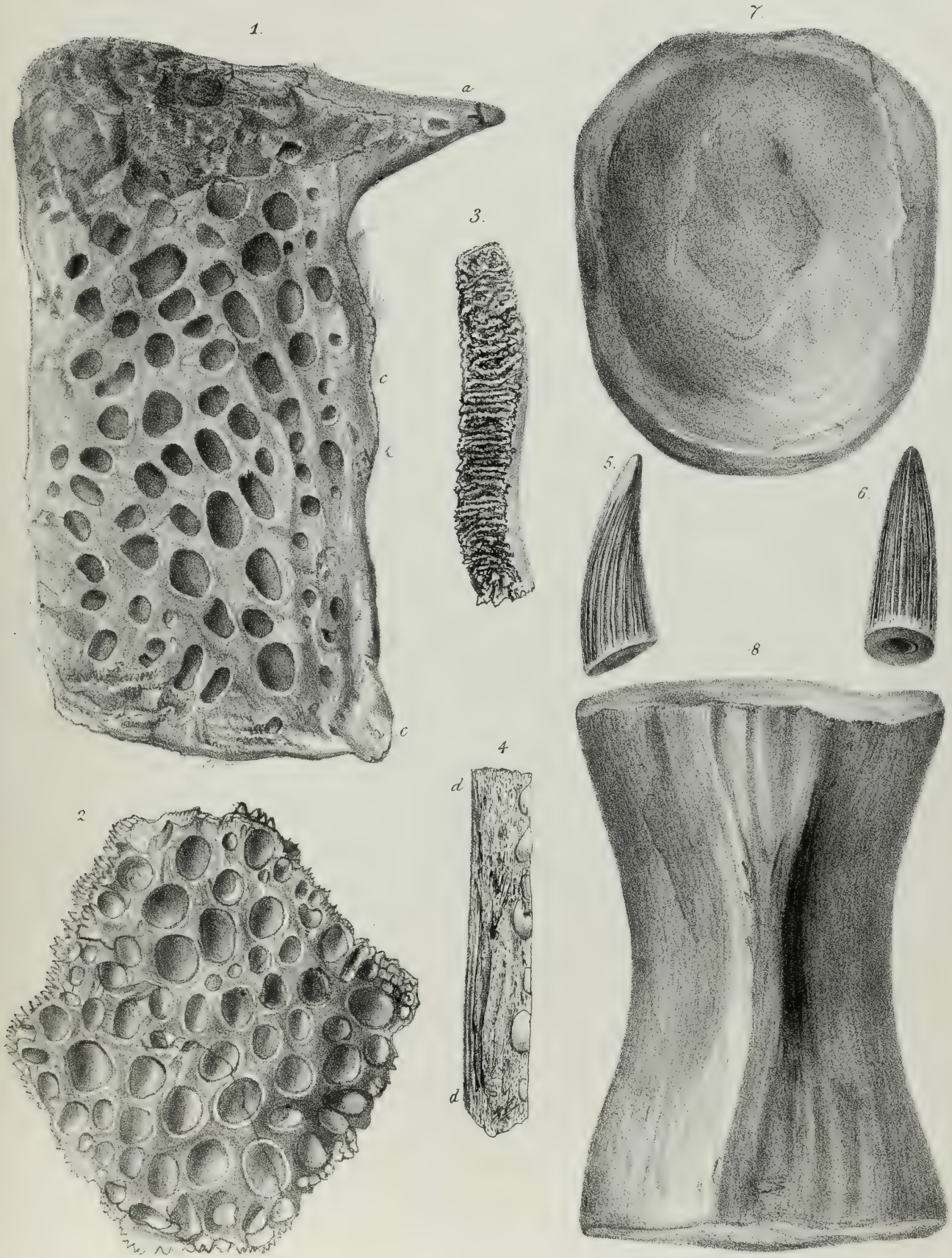
1. Dorsal scute, outer surface.
2. Ventral scute, outer surface.
3. Sutural margin of ventral scute.
4. Section of ventral scute.

Suchosaurus cultridens.

5. Side view of crown of tooth.
6. Hind view of crown of tooth.
7. Hind articular surface of centrum of dorsal vertebra.
8. Under surface of centrum of dorsal vertebra.

The subject of fig. 1 is from the Limestone Series of the Middle Purbeck.
The subject of figs. 2—4 is from the Wealden of Cuckfield.
The subjects of figs. 5—8 are from the Wealden of Tilgate.

All the figures are of the natural size.



On stone by J. Erxleben.

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1–4. GONIOPHOLIS CRASSIDENS.
5–8. SUCHOSAURUS CULTRIDENS.

PLATE V.

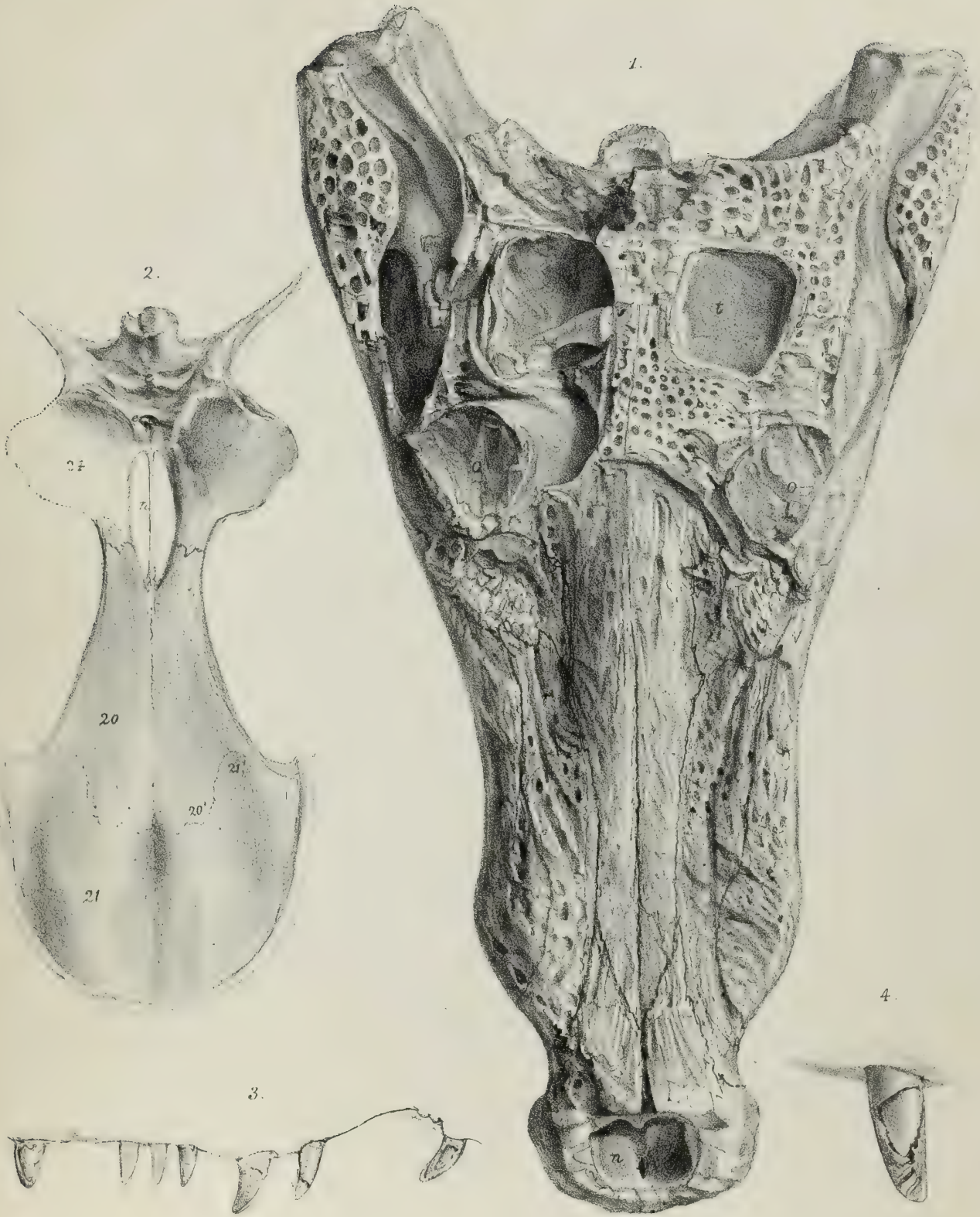
Goniopholis simus.

Fig.

1. Upper surface of skull.
2. Portion of the palatal surface of skull.
3. Portion of the left alveolar border and teeth of upper jaw.
4. The largest (2nd canine) of the upper series of teeth.

From the Limestone Series of the Middle Purbeck.

Figs. 1—3 : half nat. size ; Fig. 4 : nat. size.



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GONIOPHOLIS SIMUS.

PLATE VI.

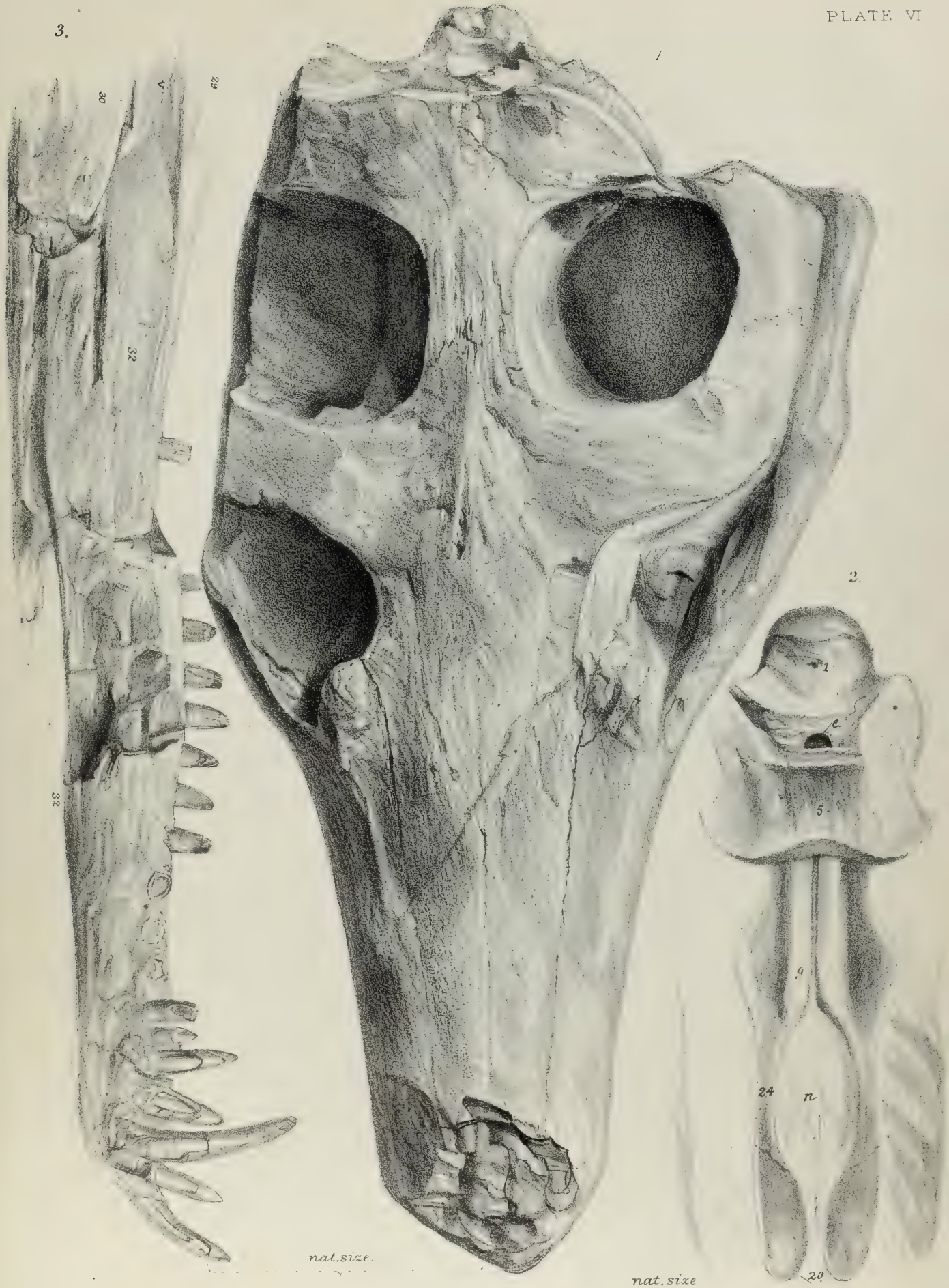
Petrosuchus levidens.

Fig.

1. Portion of skull, upper surface.
2. Portion of skull, palatal surface.
3. Portion of right ramus of mandible.

From the Limestone Series of the Middle Purbeck.

All the figures are of the nat. size.



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PETROSUCHUS LEVIDENS.

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THE

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THE

BRITISH

PLEISTOCENE MAMMALIA.

BY

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PART A.

A PRELIMINARY TREATISE ON THE RELATION OF THE PLEISTOCENE MAMMALIA TO THOSE NOW LIVING IN EUROPE.

(PAGES *i—xxxviii.*)

LONDON:
PRINTED FOR THE PALÆONTOGRAPHICAL SOCIETY.
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J. E. ADLARD, BARTHOLOMEW CLOSE.

A PRELIMINARY TREATISE[1]

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THERE is no province of investigation which promises a richer harvest than that stretching away from the borders of history back to the point, where the remote geological horizon stands clearly defined. In it lies hidden the clue to those conditions from which the present physical state of Europe arose, the climate, the distribution of land and water, and the various races of animals which now inhabit its surface. An adequate idea of what went before is indispensable to the right understanding of the present order of things. My aim in this work is to see what evidence of the past is afforded by the races of animals that have successively inhabited Europe from the Pleiocene down to the present day. Such an attempt, however feeble, is at the present time singularly opportune. Since the days when the immortal Cuvier made the scattered bones in the gypsum quarries of Montmartre reveal the strange forms which dwelt in France in Eocene times, the materials for a history of the Pleistocene Mammalia have gradually been accumulated.

In France MM. de Serres, Croizet and Jobert, Gervais, Gaudry, and many others, have explored the caves and river-deposits with remarkable success, and the late M. Lartet, in

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In France MM. de Serres, Croizet and Jobert, Gervais, Gaudry, and many others, have explored the caves and river-deposits with remarkable success, and the late M. Lartet, in

[1] The first thirty-eight pages of this preliminary treatise were written in 1872.

conjunction with our countryman Mr. Christy, has unfolded a chapter in the history of man that had been hidden for untold centuries in the Reindeer caves of Auvergne. In Belgium the labours of Dr. Schmerling have been successfully resumed by M. Dupont, and the same race of men which inhabited Auvergne has been proved to have lived in the valley of the Meuse. In our own country the exploration of caves, begun by Mr. Whidby in 1816, has been carried on by MacEnery, Austen, Falconer, Busk, Pengelly, Sanford, myself, and others, and at the present time is being prosecuted by the British Association in Devonshire and Yorkshire, while the fluviatile deposits have been worked out by Lyell, Evans, Prestwich, Austen, and Lucy, and many others. The caves also of Germany, Gibraltar, Sicily, and Malta have been ransacked, and the evidence offered by their contents has been carefully tabulated. Nor has the badly defined interval of time between the Pleistocene on the one hand and history on the other been neglected. The archæologists have proved that throughout Europe there existed before the dawn of history bronze-using races, unacquainted with iron, and that they were preceded by men ignorant of all metals, except gold, and shaping implements and weapons out of bone and stone for their various needs. The naturalists have been studying the class of animals, wild and domestic, by which these ancient prehistoric dwellers in Europe were surrounded. Prof. Nilsson in Sweden, Dr. Steenstrup in Denmark, and Dr. Rütimeyer in Switzerland, have described the prehistoric fauna of their respective countries, and my own investigation into the Mammalia associated with the remains of men of the neolithic, bronze, and iron ages, has resulted in the proof that the alluvia and peat-bogs, termed "recent" by Sir Charles Lyell, are contemporaneous with the three archæological divisions. Within the frontiers of history evidence of the changes in the mammal-fauna lies buried in the works of the classical writers, and of mediæval annalists, in the legal enactments, and the metrical graces of pious monks.

To reduce this enormous and varied mass of facts to a definite order, and to form a connected story of the past, has been attempted by several writers during the last few years. Sir Charles Lyell, Sir John Lubbock, and more recently Dr. Hamy, have grappled with the problem of the antiquity of man and the growth of his civilisation, making man the centre around which all the phenomena are grouped.

In this treatise the subject will be approached purely from the point of view offered by natural history, which is, to a great extent, complementary of that offered by man, and the most important facts out of the vast number which have been recorded will be woven, so far as may be, into one continuous narrative.

The wild animals are of equal interest to the geologist, the archæologist, and the historian; for they afford to the first a means of classifying the deposits with which he has to deal, while in archæology and history they bear a direct relation to the members and civilisation of the human dwellers in the same region. They are also valuable to the geographer and physicist, since the occurrence of the same animals in islands as on the adjacent continent implies a continuity of land between them in former times, and the

range of certain creatures over areas in which they are not now living points to a change in climate and condition of life. The European wolf would obviously not have been introduced into England or Ireland by the hand of man, nor could it have crossed over the existing seas, and therefore it must have arrived before these impassable geographical barriers were formed. That the European lion lingered in the mountainous region of Thessaly as late, to say the least, as the days of Xenophon, is evidence of a sparsely populated, uncultivated district, just as the ancient sojourn of the reindeer in Caithness proves that the climate in Scotland was more severe formerly than at the present day. In all respects the Mammalia are worthy of notice, but more especially from the fact that they constitute a strong bond of union between geology, archæology, and history—three branches of human knowledge that at first sight appear isolated from each other.

The conclusions which may be drawn from the Mammalia as to the changes which have taken place in climate and geography are most important. The caves of Great Britain throw light on those of France, Belgium, and Germany, and together with those of Spain, Malta, and Sicily, enable us to restore, in some measure, the various states through which the continent has passed, outside the reach of history; and the deposits of ancient rivers enable us to complete the sketch. The sequence of events with which we have to deal is, to say the least, as trustworthy as that offered by the historian. Indeed, our evidence is, in a sense, more trustworthy than that on which the historical narrative is based. Our facts have not been tampered with, or coloured by filtration through the mind of a chronicler more or less biassed. His must be carefully sifted and analysed before they can be used at all. Nor is our prehistoric record more broken or superficial than that offered by the historian, which consists, in the main, of battles, and sieges, and treaties, and the foreign relations of the country which is described, but which tells us little or nothing of the domestic and social life of the people on which true national greatness really depends. We know almost as little of the social life of Britain under the Romans, as of that of the savages who lived on the Pfahlbauten of Switzerland, or who hunted the reindeer in Auvergne. We know almost as little of the inhabitants of Pompeii as of the buried Neolithic villages of Santorin.

The important question of the divisions of time, outside the reach of history, must be examined, as well as the value of the animals in classification, the migration of species, and the incoming and the disappearance of certain groups. The introduction of the domestic animals, also, must be treated,—a point on which history and archæology between them offer most valuable testimony.

The method of investigation adopted in this treatise is to start from a firm basis of history, and then to pass backwards in time to the consideration of the animals which have left their remains as the sole evidence of their former existence in the several countries. I shall pass from the Historic to the Prehistoric, and then, finally, to the Pleistocene groups of animals.

Nomenclature—Definition of terms.

The rest of this chapter must be devoted to the difficult question of the nomenclature of the great divisions of past time, with which we shall have to deal, and of the geological periods which preceded them. The Tertiary or Cænozoic strata were divided by Sir Charles Lyell, in 1833,[1] into three great groups, according to the percentage of existing Mollusca, which was presented in a comparison of 3000 fossil with 5000 living forms. The Eocene (ἠώς, dawn, καινὸς, new) or the earliest group contained about $3\frac{1}{2}$ per cent. of living shells, and thus, to speak metaphorically, was characterised by the dawn of the testaceous fauna now living in the sea. In the Meiocene (μείων καινὸς) group alone, the existing forms were much more abundant, being about 17 per cent. of the whole, and considerably less than one half. The upper group was termed Pleiocene (πλείων, more, καινὸς, new), presented from 35 to 50 and even 90 per cent. of living Testacea. The vast number of fossil species which have since been added to those which formed the basis of this classification has not materially altered its value, but merely rendered the strict definition of the percentages impossible.

This system of classification, based on the examination of the creatures living in the sea, cannot, strictly speaking, be applied to the dwellers on the land. In the Eocene strata, for example, no living species of Mammalia has ever been discovered, nor even in the Meiocene. Nor, indeed, does it apply to the land vegetation. The Laurel, Sequoia, and Poplar, found in the Chalk of Kansas and Nebraska by the American geological surveyors, are so like those which flourished in Europe during the Meiocene that Professor Heer had no hesitation in assigning them to the Meiocene age. It follows, therefore, that the change in terrestrial life does not proceed at the same rate as that of the marine fauna, and that it is impossible to reason from the one to the other. But, nevertheless, the names are so useful in classification that it is more convenient to adopt them as mere names, without any idea of percentages, than to discard them as being literally untrue according to their original definition. They embalm the important truth of the gradual evolution of animal and vegetable life, and will remain in the literature of geology as a monument of the sagacity of their inventor.

So far the nomenclature is very simple and accepted by all naturalists; but the names of the rest of the divisions by which geology is linked on to history are very complex and badly defined. Sir Charles Lyell made the Tertiary period to end with the Pleiocene,[2] drawing a hard and fast line between it and the succeeding or Post-pleiocene age. It is undoubtedly true that, looking at the marine shells only, some few

[1] 'Principles,' 1st edit., 3rd vol., 1833; 'Antiquity of Man,' 1st edit., p. 3.

[2] 'Antiquity of Man,' 1st edit., chap. i; 'Student's Elements of Geology,' pp. 108-9 (1870).

Pleiocene species may have become extinct, while in the latter, or as he terms them the "Post-tertiary strata," all the marine forms are still living in the European seas. But that is not a difference of sufficient magnitude to establish so important a division. Most of the living marine Mollusca, if not all, are to be found in the Pleiocene strata, and therefore there is no break of molluscan life to indicate the close of a great life-period. Nor in the case of the Mammalia living on the land is there any marked break of continuity from the Meiocene down to the present day; but all are so interlaced together that the line of demarcation between the Tertiary and living is, to a great extent, arbitrary. The Pleiocene, therefore, cannot be viewed as the closing stage of the Tertiary or Cænozoic period, but the latter term must be extended so as to embrace the lapse of time from the Eocene down to the present day.

The term Pleistocene (or πλεῖστος, most, καινὸς, new), first used by Sir Charles Lyell in 1839, and subsequently discarded for "Post-pliocene," seems to me to be the most convenient name for the stage which followed the Pleiocene, since so far as the mammalian life is concerned the numbers of living species preponderated over the extinct in the proportion of at least three to one. The terms "Postpliocene," as well as the "Quaternary" of the French and the "Quarternary" of some of the American geologists, lie open to the objection urged above, that they convey a false idea of the magnitude of the break between the Pleiocene and the succeeding period. I shall therefore in this treatise confine myself to the use of Pleistocene, a name widely used both in Britain and on the Continent, and a name that is the etymological consequent of Eocene, Meiocene, and Pleiocene.[1] The consideration of the subdivisions of the Pleistocene, preglacial, glacial, and postglacial, must be postponed till I can bring forward the evidence by which I have been led to reject them as being of no value in the classification of the mammalia, a view held in common by Prof. Phillips[2] and by Mr. Godwin-Austen.[3] Sir Charles Lyell in like manner ignored the glacial period as a means of subdividing the "Post-pliocene" life-period.[4] The terms are merely valuable as denoting physical changes in Britain, North Germany, Russia, and Scandinavia.[5]

The classification of the Tertiary groups of life from the Eocene to the Pleistocene is based on the recognition of the gradual evolution of animals which bear an increasing resemblance to those which are now alive. At this point, however, this principle of classification is valueless, since, from the Pleistocene to the present day, there is no evidence of the addition of one wild creature to the existing fauna with the exception of the common

[1] M. Gervais, the eminent writer of the 'Paléontologie et Zoologie Françaises,' comes to the same conclusion, and for the same reasons, see edit. 1859. See also 'Nouvelles Recherches sur les Animaux Vertèbrés,' 4to, 1869, p. 31.

[2] In a letter to the writer in September, 1871.

[3] 'Quart. Geol. Journal,' 1869, p. 216.

[4] 'Antiquity of Man,' chapter i.

[5] Since this paragraph was written Sir Charles Lyell has withdrawn the term Post-pliocene, 'Antiquity of Man,' 4th edit., 1873, Chapter 1.

rat and possibly the true elk. The present wild animals of Europe are merely the survivors of a large and varied group that lived on the Pleistocene continent, the characteristic Pleistocene members of which have disappeared one by one from the incidence of various causes. And yet there is a striking difference, which cannot be overlooked, between the Pleistocene and the succeeding life-periods. In the Introduction to the British Pleistocene Mammalia,[1] and subsequently, and at greater length, in the 'Proceedings of the Prehistoric Congress,'[2] I have classified the Post-pleistocene phenomena strictly from the stand-point offered by history. All those of which there is any record are termed historic, while those which lie outside history are termed prehistoric.

The Prehistoric extends from the borders of history back to the Pleistocene Period, and is characterised by the advent of the swine, dog, sheep, goat, and the domestic horse and oxen into Europe under the care of man. The invasion of Europe by this group of life is from a zoological point of view of the very highest importance, since from that time the domestic animals have been in continual rivalry with the wild, and have gradually encroached on the ancient haunts of the latter. It requires no extraordinary foresight to see that this process will go on, until the few wild animals left to represent the Pleistocene Fauna will be preserved in Europe merely for the sport and luxury of the wealthy classes. The beginning of this revolution in animal life is the great event which distinguishes the Prehistoric from the Pleistocene Period, and, coupled with the disappearance of the characteristic animals of the latter period, such as the mammoth and woolly rhinoceros, constitutes a difference of very high classificatory value. There is, to say the least, as much difference between the Prehistoric and Pleistocene Mammalia as between the latter and the Pleiocene.

Sir Charles Lyell massed together the Prehistoric and Historic divisions under the head "Recent,"[3] using the term in relation to the enormous antiquity of the preceding geological period, and giving as a characteristic difference the absence of all the extinct mammalia. The presence, however, of the extinct Irish elk in the peat-bogs of Ireland, Scotland, and England, which form one of the recent divisions, renders it impossible to accept the definition. It seems to be far more convenient to draw a distinction between the Prehistoric and the Historic animals than to mass them together in one group. Nevertheless, it must be admitted that the only difference between their respective groups of mammalia is presented by the gradual disappearance of the larger wild animals from certain areas, the extinction of one, the Irish elk, and the importation and naturalisation of a few species, such as the buffalo in Italy and the fallow-deer in Britain, by the hand of man.

The Prehistoric Period includes the age of polished stone, or the neolithic, the bronze,

[1] Palæontographical Society vol. for 1864; Introduction, 'Brit. Pleistocene Mammalia,' by W. Boyd Dawkins and W. A. Sanford.

[2] 'International Congress of Prehistoric Archæology,' Norwich, volume for 1868, p. 269.

[3] 'Antiquity of Man,' chapter i; 'Student's Elements of Geology,' pp. 108-9.

and the iron ages, since the prehistoric animals are found in and around the dwellings and the burial places of the men who lived in those times.

The Historic Period embraces the lapse of time from the first authentic record of any given country down to the present day, and its beginning necessarily varies in different regions. In Britain it would begin with the first invasion of the Romans; in Gaul with its conquest by the Roman legions; and in Germany with the Annals of Tacitus. In the countries, however, bordering on the shores of the Mediterranean, in the great centres of civilisation, Rome and Greece, it would extend much further back from the present time, and would embrace a time during which there were no records of the regions lying to the north, that is to say, of central and northern Europe. It is a most important thing to bear in mind that there is no absolute historic period applicable to all parts of Europe. While the master minds of Greece were earning imperishable fame by their writings, the rude nations of Gaul, Germany, Britain, and the north were probably constructing the dwellings, tumuli, and stone circles which excite our admiration. It would be as unfair to call the Parthenon prehistoric as to term the Pfahlbauten of the Swiss lakes historic, although it may be that both were in existence at the same point of time.

Table of the divisions of the Tertiary or Cænozoic Period.

The following are the divisions of the Tertiary or Cænozoic Period adopted in this essay.

	Deposits containing Mammalia.
I. Historic = Recent, in part, of Sir Charles Lyell.	I. Caves, Peat-bogs, Alluvia. Refuse-heaps, houses, camps, tombs.
II. Prehistoric = Neolithic, Bronze, Iron Ages = Recent, in part, of Sir Charles Lyell.	II. Caves, Peat-bogs, Alluvia, dwellings and burial places of man. Refuse-heaps.
III. Pleistocene = Quaternary of French Geologists = Post-pleiocene of Sir Charles Lyell = Palæolithic age in part.	III. Caves, brick-earths, and ancient river-gravels. Refuse-heaps. Glacial deposits.
IV. Pleiocene.	Deposits of rivers and ancient lakes. Estuarine deposits. River-deposits. Marine deposits.
V. Meiocene.	Ditto.
VI. Eocene.	Ditto.

The Mammalia which lived in the first three of these stages or divisions, are those to which this treatise will be principally devoted, but we shall be obliged also to examine the relation of the Pleistocene to the Pleiocene, and those peculiar conditions under which the mammals of the latter yielded place to those of the former age.

CHAPTER II.—HISTORIC MAMMALIA OF GREAT BRITAIN AND IRELAND.

The Historic Starting-point — British Wild Animals — British Domestic Animals— The English Breeds of Oxen—The Romano-Celtic or Brit-Welsh Breed—Animals eaten by the Romano-Celts or Brit-Welsh—Principal Animals in Britain at beginning of Historic Period — Physiography of Britain — The Wild and Domestic Animals of Ireland—The Principal Mammalia of Britain and Ireland— Conclusion.

The wild animals afford a valuable insight into the physical condition of the country which they inhabit: they cannot compete with man in the struggle for life, and if their environment changes they must either die out or become changed in a corresponding degree. Consequently they are of great interest to the student of history, since they enable him to form some idea of the relation of cultivated to uncultivated lands, as well as to the physicist, since the change in the mammal fauna, which in some cases cannot be assigned to the hand of man, implies a corresponding change in the geography and climate. In the present and the succeeding chapters we shall examine the larger and more important species which have inhabited Europe from the beginning of history to the present day, and we shall see what inferences may be drawn from the gradual restriction of their areas. Among the domestic animals, also, the two breeds of oxen, which are especially interesting from an historical point of view, must not be omitted.

The Historic Starting-point.

It is extremely difficult, if not impossible, to define with accuracy the point where legend shades off into history; but it will be convenient, for the purposes of this work, to draw the line at the first beginning of a connected and continuous narrative, rather than at the first isolated notice of any given country. If we accept this definition, the history of Northern France cannot be said to begin earlier than the campaigns of Cæsar, B.C. 55, who may justly be termed the first historian of Northern Germany and Britain. In Southern Gaul the founding of Massilia by the Phocæans (B.C. 539) is the earliest record, but we are ignorant of the sequence of events in the centuries which elapsed between that date and the treaty which the Phocæan colonists made with the

Romans B. C. 218. The history of Spain may be said to begin with the founding of Gadeira, B. C. 1200 (?), by the Phœnicians; but between that enormously remote and uncertain date and the conquests of the Carthaginians in Spain, B. C. 241, we have no historical trustworthy record. In both these cases the latter date rather than the former will be taken. To attempt to define the relation of history to legend in ancient Greece and Rome would be outside the scope of this work, and it is much safer, in the present state of our knowledge, to leave it uncertain.

We shall begin with the Historic Mammalia of Great Britain and Ireland.

Wild Animals living in Britain in the Historic Period.

The utmost limits of history in Great Britain cannot be extended farther back than the brief and transient invasion of Julius Cæsar; and, indeed, of the interval between that event and the subjugation of the country under Claudius we know scarcely anything.

Our wild animals live for the most part on sufferance, and are so well known that it is scarcely necessary to treat them with more than a passing allusion. The common rat (*Mus decumanus*), which had passed into Southern Russia by the year 1727, from Asia, arrived in Britain certainly before the year 1730, and has since nearly exterminated the black species (*Mus rattus*).[1] It is the only wild animal which is known to have invaded Europe in the Historic age. The fox, protected by the love of hunting, is very generally distributed; the badger is by no means rare, although from its nocturnal habits and its caution, it is seldom seen; and the wild cat lingers still in South Wales, near Tenby, and in the North Riding of Yorkshire, and is not very rare in Scotland. The otter is now comparatively scarce in the rivers, but is widely spread. Besides the common hare, the Alpine or white species, *Lepus variabilis*, lives in the Highlands of Scotland, seldom descending into the valleys, and is a living monument of the period of intense cold in Britain. The red deer is wild only in the Highlands and in Exmoor forest, while the wild roe is only to be found in Scotland. All these animals have suffered severely from the competition of the farmer, and to what extent can only be realised by examining the records of some two centuries ago, from which it is clear that the almost chivalrous regard for some of these animals is a product of modern luxury. "The fox," writes Lord Macaulay, "in the year 1641 was considered a mere nuisance, whose life is now, in many counties, held almost as sacred as that of a human being. Oliver Saint-John told the Long Parliament that Stafford was to be considered, not as a stag or a hare, to whom some law was to be given, but as a fox, who was to be snared by any means, and knocked on the head without pity. This illustration would be by no means a happy one if addressed to country gentlemen of our time; but in Saint-John's

[1] Pallas Glires 4to.

days there were not seldom great massacres of foxes, to which the peasantry thronged with all the dogs that could be mustered; traps were set, nets were spread, no quarter was given, and to shoot a female with cub was considered a feat which merited the warmest gratitude of the neighbourhood."[1]

The stag was so abundant in the south of England, as recently as the reign of Queen Anne, that while *en route* between London and Portsmouth she saw a herd of no less than four hundred. From her days the number of wild species in Great Britain has suffered no diminution, since the more formidable animals had already been destroyed.

After the English invasion, when the populous Roman province of Britain had been devastated by fire and sword, wolves increased to such a degree that they are deemed worthy of notice in the public records. At Flixton, near Filey, in Yorkshire, writes Camden,[2] an hospital was built in the time of Æthelstan for defending travellers from wolves, that they should not be devoured by them. In the reign of one of his successors, Eadgar, we hear of a tribute of three hundred wolves' heads laid on Ludwal, a prince of Merioneth, who, according to William of Malmesbury, paid this tribute for three years, and desisted on the fourth, because he could not find any more.[3] He very likely drove them out of his territory, but they still continued numerous in other places. The statement in the metrical account of the battle of Hastings, that Duke William collected and buried his own slain, while he left the English a prey to the birds and wolves,[4] is probably literally true, because the tangled thickets of the Andredsweald must have been the lurking places of wolves at the time. In 1281 they had increased so much in the counties of Gloucester, Worcester, Hereford, Shropshire, and Stafford, that one Peter Corbet was ordered by Edward I to destroy them by any means that he could.[5] This is the last historical notice which I have been able to verify. Camden, however, mentions them as formerly infesting the Peak country, and there is said to be preserved at Exeter a record in which they are mentioned as infesting Devonshire after this time. Taking everything into consideration it seems very probable that they were exterminated in England and Wales before the end

[1] 'History of England,' vol. i, 1858.

[2] Camden's 'Britannia,' edit. Gibson, vol. ii, p. 110.

[3] Wil. Malm., ii, 155, vol. i, p. 251, edit. Hardy.

[4] 'De Bello Hastingensi Carmen,' by Guido, Bishop of Amiens.

[5] 'Rymer Fœdera,' folio, Lond. 1705, p. 168. 1281, An. 9 E. I. "Rex omnibus Ballivis, &c. Sciatis quod injunximus dilecto atque fideli nostro Peter Corbet quod in omnibus Forestis et Parcis, et aliis locis infra comitatus nostros Gloucestr. Wygorn. Hereford. Salop. et Stafford. in quibus lupi poterunt inveniri, lupos cum hominibus, canibus et ingeniis suis capiat, atque destruat modis omnibus quibus videntur expedire.

"Et ideo vobis mandamus quod eidem Petro in omnibus, quæ ad captionem luporum in comitatibus prædictis pertinent, intendentes sitis et auxiliantes, quotiens opus fuerit et prædictus Petrus vobis scire faciet ex parte nostrâ. In cujus &c. duratur quamdiu nobis placuerit. Teste Rege apud Westminst. decimo quarto die Maii."

of the fourteenth century; for had they been present after that date, their ravages would certainly have been placed on record. Their memory is preserved in several names of places in different parts of England. "The spacious palace," for example, called Wolvesey, built close to the east side of Winchelsea Cathedral by Bishop Henry in 1137, and Wolvey, near Nuneaton, where Edward IV was taken prisoner by the Earl of Warwick, after the battle of Dane Moor, may be quoted as examples.

The wolves lingered some time longer in Scotland than in England, as might be expected from the country affording better cover, and in the eleventh or twelfth century they were a scourge sufficiently serious to be mentioned in a litany along with caterans.[1] The last wolf in Scotland was killed, according to Pennant, by Sir Ewan Cameron in the year 1680.

The wild boar became extinct certainly before the reign of Charles I, for he obtained a pair with great trouble and expense from Germany[2] and turned them into the New Forest. Like those which General Howe turned into his forest in Hampshire at the beginning of this century, they were destroyed by the exasperated rustics.

The memory of Wolves and Boars is preserved in many names of places, such as Wild Boar's Clough, near Macclesfield, and Wolvesacre, near Whitchurch, in Shropshire.

In the twelfth century the beaver was hunted for its fur on the banks of the Teivi, in Cardiganshire,[3] and before that time had left the names of Beverstone in Gloucestershire, Bevercoates in Nottinghamshire, and Beverley in Yorkshire, as evidence that it was known to the English conquerors of Britain. In Wales it has given its name to no less than three lakes,[4] and its fur is set apart in the laws of Howel Dha[5] for the use of the Queen.

The current belief that the brown bear lingered in Britain to be exterminated in Scotland by the founder of the Gordon family in 1057 is unsupported by any documentary evidence which I have been able to discover.[6] There can, however, be no doubt that it was in Britain during the Roman occupation, since it is mentioned by the poet Martial as being Caledonian; and since I have met with its remains in Colchester, in a refuse-heap which was accumulated by the Roman provincials.

To the animals inhabiting Britain during the Historic Period, we must add two other

[1] "A cateranis et latronibus, a lupis et omni mala bestia, libera nos Domine," 'Litany of Dunkeld,' lxii. See preface, p. xxiv, 'Kalendar of Scottish Saints,' 4to, 1872, by the Bishop of Brechin. This litany is later than 1046.

[2] Lord Macaulay omits to notice that these wild boars were obtained from Germany, and consequently ascribes their extinction to the time of the civil wars. On this point see Youatt, 'The Pig,' p. 29; Bigland, 'British Quadrupeds,' pp. 449-50.

[3] Giraldus Cambrensis, 'Topographia Hiberniæ,' p. 709.

[4] Llyn-yr Avangk. See Camden, 'Britannia,' edit. Gibson, vol. ii, p. 41.

[5] 'Ancient Laws and Institutes of Wales,' vol. ii, Venedotian Code. This was made between the death of Homel Dha and the year 1080.

[6] The crest of the Gordon family is not three bears', but three *boars'* heads.

species respectively of northern and southern origin, the reindeer and the fallowdeer. In the 'Orkneyinga Saga'[1] the Earls Ronald and Harold are incidentally mentioned to have been in the habit of crossing over to Caithness in the summer to hunt the reindeer and red deer. The authors of the 'Saga' must have been well acquainted with the reindeer in Norway, Sweden, and Ireland, and there is, therefore, nothing improbable in the inference that the "Hreina" were undoubtedly reindeer. The Romans never conquered Caithness, and the Highlands of Scotland were so strange to the English in the Middle Ages that, even so late as the time of William III, they were looked upon very much as we now view the extreme north of Lapland. The hills of Caithness lie in the same parallel of latitude as the south of Norway and Sweden, in which countries the animal was living at the time. Reindeer-moss is very abundant, and the only condition of life which is wanted to make Scotland still habitable by the reindeer is a greater severity of cold. When we consider, also, the abundance of the remains of the animal in the Scotch peat-bogs, and that it undoubtedly was an article of food in the Neolithic age in that very district, there is every reason for believing in the historical value of this incidental notice in the 'Saga.' We feel, therefore, bound to admit the fact that the reindeer lived in Caithness during the time that Henry II occupied the throne of England, and Alexander Neckam was writing his history. When Cæsar wrote his 'Commentaries' the animal had certainly forsaken Gaul and taken refuge in North Germany. Before his landing in Britain it had most likely departed from the portion of the island which subsequently formed the Roman province of Britannia. If this did not take place before the Stone or Bronze Age in England the animal must have become very rare; for, while other objects of the chase are represented by vast quantities of bones, it is as yet unknown in deposits of these ages in England. It most probably, therefore, had taken refuge in Caithness before our history began. It probably became extinct in this country about the same time as the beaver.

The second, or the semi-domesticated fallow-deer, was introduced by the Romans probably along with the pheasant,[2] and its remains are found in their refuse-heaps at London Wall and Colchester. In the Middle Ages it was an article of food almost as common as the stag.

[1] 'Orkneyinga Saga,' 'Historia Orcadensium,' 'Jarla Saga,' 1670, edit., Jonas Jonæus.

[2] The pheasant is very generally considered to have been introduced into this country from the east during tne Crusades, but is proved to have been sufficiently abundant in the neighbourhood of London to be no very great luxury, in the middle of the 11th century, by the following passage, for which I am indebted to Professor Stubbs:—"Erant autem tales pitantiæ unicuique Canonico: A Festo Sancti Michaelis usque ad caput jejunii aut xii merulæ, aut ii agauseæ (agace—magpie, Ducange), aut ii perdices aut *unus phasianus* reliquis temporibus aut ancæ aut gallinæ." 'De Inventione Sanctæ Crucis nostræ in Monte Acuto,' &c., edit. W. S. Stubbs, M.A., 1861. These allowances were made to each canon in Waltham Abbey and their households by Harold, the founder, in 1059. The fact that the Romans certainly introduced the fallow-deer, and their well-known habits of importing wild animals for sport, render it very probable that they introduced the pheasant, since we do not owe any of our wild or semi-wild animals to English or to Dane. The passage is also very interesting from the relative estimation in which the birds were held, and from one pheasant being considered the equivalent of *two* magpies.

Domestic Animals of Great Britain.

The wild animals could not have found their way, unaided by man, into Britain after the time that it was severed from the Continent, and their advent, therefore, must date back before that severance took place. It is clear, also, that the more obnoxious of them have been extirpated by the hand of man. The domesticated animals, on the other hand, have increased in numbers, and branched off into varieties in exact proportion to the amount of trouble bestowed by man on the selection of their different points. The rapidity with which they have changed has rendered it almost impossible to trace any of the known varieties far back by their external form. The dogs of Elizabeth's time would present almost the appearance of a different species[1] as compared with those with which we are familiar, and if the horse and the cattle have changed less it is due to their ministry to the use, rather than the caprice, of man.

The genealogy of the domestic hog has been ascertained by MM. Rütimeyer, Nathusius, and Schütz, with great accuracy, and Dr. Darwin[2] has summed up the evidence with judicial impartiality. It is traced, by these observers, to two distinct strains, the one being the wild boar, which is found throughout the temperate and hot regions of Europe, Asia, and in North Africa, and that which is termed by Nathusius the *Sus Indica*, of Pallas, and which is known commonly as the small, short-legged, and short-headed pig of Siam and China. The former, or the *Sus scrofa* group, strongly resembles the wild boar, but the skull is higher and broader, and the hinder part of the head is more upright. These two strains have been so profoundly affected by crossing that their dissimilarity is being rapidly obliterated, the resultant being more valuable than either of the extreme forms. According to Nathusius the infusion of one thirty-second or even one sixty-fourth of the blood of the *Sus Indica* is sufficient to modify the shape of a skull of *Sus scrofa*. The probable derivation of these two domestic forms will be discussed in the following chapter. The present breeds are the result of a careful selection.

The earliest mention of the domestic cat in Britain is to be found in the laws of Howel Dha,[3] in which the price of a blind kitten is laid at one penny, of a kitten with its eyes open at twopence, and of a cat perfect in all its faculties, and a good mouser, at fourpence. The penalty of killing the king's cat is assessed at eightpence. These laws were probably codified at the end of the tenth or in the eleventh century, although many of the enactments are probably older. It would therefore follow that the animal was known in Wales before the time of the first Crusades, which is the generally accepted

[1] Charles Darwin, 'Variations under Domestication,' vol. i, chapter 1.

[2] 'Rütimeyer, 'Fauna der Pfahbauten.' Nathusius, 'Schweinsschädel—Die Racen der Schweines.' Darwin, 'Variation,' vol. i, chapter iii.

[3] 'Leges Walliæ, or Ancient Laws and Institutes of Wales.'

date of its introduction into Britain. It was probably derived from the south of Europe, and may have been introduced during the later times of the Roman occupation. It is, however, unrepresented in the numerous refuse-heaps of Roman age.

The hornless breeds of sheep date back in our country from the days of the Romans, since the hornless skulls have been discovered, associated with Roman remains, in London.[1] From the analogy of the cattle it is certain that they were derived from a horned race, such as the Welsh, or old Irish, or Exmoor breeds. Nevertheless, the horned is more abundant in the Roman refuse heaps than the hornless, and in those days was the dominant breed.

The polled, or hornless, cattle of the present day have undoubtedly been derived through careful breeding from the horned cattle. The Galloway breed has lost its horns principally through the care of the grandfather of the present Earl of Selkirk, to whom I am indebted for the account given in full in the notes. Some fifty or sixty years were consumed in bringing the animal to its present shape and form.[2]

The English Breed of Oxen.

Among the numerous varieties of living horned cattle there are two distinct stocks which graduate into each other, namely, the small dark Welsh and Scotch mountain cattle, and the larger red and variegated breeds which now are to be found throughout Britain and Ireland, except in a few isolated districts. The relation between these two breeds is of great historical importance, because it throws light on the vexed question as to the extent to which our English ancestors harried and ruthlessly destroyed the Roman provincials, whom they invaded. We will first of all examine the probable date of the introduction of the larger breed, which, according to Professors Nilsson and Rütimeyer, is

[1] In coll. of Gen. Lane Fox.

[2] "The breed a hundred and fifty years ago was not generally 'polled,' *i. e.*, without horns, though there was always a good many polled ones amongst them. Polled ones are found in every breed. My informant was an old man who died about thirty years ago, he being then near ninety. He was the son of the man who tended the cows for my grandfather, and had been employed among cattle all his life; in his old age, while still able to work, he tended my cows. His name was James McKinnan, and he was a man whose recollections seemed always remarkably clear. He had been with cattle as far as Norfolk to St. Faith's fair. He told me that in the days of his childhood a Norfolk feeder, who bought many of the Galloway cattle, fancied those without horns, and would give 2s. 6d. or so more for a polled than for a horned beast. This set the fashion, and the people began first to look for polled bulls and none other; then they preferred the polled cows, &c., to breed from, and thus the change was effected in, I believe, from fifty to sixty years. The horns of the Galloway beast were very ugly, drooping, and as thick at the point as at the root. I have myself seen one or two beasts with horns like that; but nowadays, when horns appear, they are generally traced to some cross with an Irish brute. Those that are born polled have a lump in the centre of the forehead, which is very hard, and will break another bull's skull for him." (Extract of a letter from the Earl of Selkirk to the author 6th March, 1867.)

descended from the wild Urus, taking as a type the living semi-domesticated white oxen with red ears which are preserved in Lord Tankerville's park at Chillingham, near Berwick. The earliest record of the animal is to be found in the Venedotian code of laws,[1] ascribed to Howel Dha, and which probably is of the tenth or perhaps eleventh century, the usage implied by the laws being probably much earlier than the codification. The fine to be paid for injury done the King of Aberfraw is a hundred cows for each hundred townships, and "a white bull with red ears to each hundred cows." In the later Dimetian code the Lord of Denevwr is to have for the infringement of his prerogative as many white cattle with red ears as shall extend in close succession from Argoel to the Palace of Denevwr, with a bull of the same colour with each score of them." In the still later Latin translation of the Welsh laws one hundred white cows with red ears were considered equivalent to a hundred and fifty black cattle. The specification of white with red ears in these passages is considered by Mr. Youatt and Mr. Darwin[2] to denote merely a difference of colour and not of breed. From, however, its continual occurrence, and from its agreement with characters of the Chillingham ox, there can be little doubt that it denotes a difference of breed; and this conclusion is rendered almost certain since, in comparison with the Welsh black cattle, it denotes the most prominent features. The size also of the Chillingham ox is about one third greater than that of the black Welsh and dark-coloured Highland cattle, the ratio between them being the same as that between the hundred white cattle and the hundred and fifty black of the 'Leges Walliæ.' The regular presents of cattle made by the Cambrian princes to the kings of England contain the same distinct specification of colour. White, too, with red ears, was the herd of four hundred oxen from the wilds of Brecknock with which Maud de Breos purchased peace, for her offending lord, of King John, through the intercession of his queen.[3] In the early Irish records white cattle are frequently mentioned.

The Chillingham cattle are very generally considered to have been once living in Britain in a wild state, because of their shyness and their aversion to man. These two characteristics, however, seem to me to be the natural result of the conditions under which they and their ancestors have lived. Because our flocks and herds, accustomed for the most part to the small fields, and housed during the severity of winter, are tame, it by no means follows that those which were turned out into the unenclosed and common lands would be equally tame. As Lord Macaulay has forcibly pointed out, our trim hedge rows and enclosures were very few and far between, even as late as the latter half of the seventeenth century. "At Enfield, hardly out of sight of the smoke of the capital, was a region of five and twenty miles in circumference, which contained only three houses and scarcely any enclosed fields. Deer, as free as in an American forest, wandered there

[1] 'Ancient Laws and Institutes of Wales.'

[2] Youatt, 'Cattle,' p. 49; Darwin, 'Variation,' vol. ii, p. 209.

[3] Youatt, 'Cattle, p. 48. I have been unable to find the authority for this in Speed's 'History of Great Britain.'

by thousands. * * * * From Abingdon to Gloucester, a distance of forty or fifty miles, there was not a single enclosure, and scarcely one enclosure between Biggleswade and Lincoln." At a still earlier period the enclosures must have been very few indeed. Under conditions of life of this kind the domestic animals must necessarily have been wilder than they are now, since they were sent out into the unenclosed lands to get their living, being, to a certain extent, independent of the care of man. In Becket's days, in the forest extending on the north of London from the meadows and pastures of the wealthy citizens there were to be found woodland bulls as well as wild boars, stags, and roes.[1] The wildness, therefore, of the Chillingham ox cannot be taken to be a satisfactory proof that it inhabited Britain originally in a feral state, any more than the same quality in the South American cattle or the horse indicates that they, too, were descended from wild American stocks. There is, however, proof of another kind which renders it impossible to believe that the Chillingham ox was ever aboriginally wild in our country. The creamy white colour of so large an animal would render concealment in underwood impossible, and cause it to fall a prey to its enemies, and its large size would render it extremely valuable to the hunter. Such a detriment to the well-being of a wild animal in so small an island could only have been avoided under the care and tutelage of man. Had it ever been wild in Britain it would have been exterminated long before the Historic Period.

The historical evidence, therefore, is decisive that a large breed of cattle was highly prized in Wales in the tenth or eleventh centuries, which very closely resembled the ox of Chillingham, and the minute specification of its characters implies the existence, at the same time, of some other breed. It is only reasonable to suppose, from the fact that all the truly English breeds of cattle now living in England are of the same stock, that in those early times the animal was that which was more usually kept by the English (Anglo-Saxon) inhabitants in Britain. Beyond this point I am unable to trace the larger breed in Britain; but its absence from the very many refuse-heaps and accumulations of bones which I have examined renders it almost certain that it was unknown during the Roman occupation. Indeed, none of the larger oxen, whether wild or domestic, have left any trace of their existence in our country at that time. Had they lived here at the time they would certainly have formed part of the food of the Roman provincials, and would have been discovered in their refuse-heaps.

We have, therefore, to account for the introduction of this larger breed into Britain about the time of the great English invasion. Before that time it was unknown; after that time it was very widely spread. If we appeal to history there are several circumstances which indicate that it was imported by the conquerors of Roman Britain from their ancient home in the district between the Rhine and the Elbe. In the Sagas and elsewhere there is ample proof that the inhabitants of Scandinavia possessed herds of

[1] "Tauri Sylvestres," 'Vita Sancti Thomæ, auctore Wilhelmo Filio Shephani,' vol. i, 8vo edit. A. Giles Oxoniæ, p. 173.

cattle. The conquest of Normandy, for example, was the indirect result of the banishment of Rollo for cattle-lifting in Norway. The pirates in those days were in the habit of taking on shipboard live oxen, and especially if they intended not merely a descent but a settlement. The Norwegian settlers in Iceland, in 874, must have conveyed oxen along with them, since we read of herds in that desolate island in the ninth century. At the beginning of the eleventh century Thorsin,[1] a wealthy Icelander, arrived in Greenland from Norway, and thence founded a colony in Vinland, taking with him sixty sailors, much cattle, and implements of husbandry. There he found pasturage so plentiful that a bull grew exceedingly strong and fierce, and frightened the Skrælingues (probably the Eskimos) with its roaring to such a degree that they burst open the doors of Thorsin's house and crowded into it in terror.

The fact that cattle were thus transported over wide and dangerous seas by the Norwegian and Icelandic colonists renders it in the highest degree improbable that their English cousins, who colonised Britain, did not also bring along with them whatever cattle they possessed. The three keels which landed at Richborough full of armed men from Jutland was the advanced guard of a great migration, which was so complete that, according to the 'Anglo-Saxon Chronicle,'[2] the ancient home of the old race was left desolate for four centuries afterwards. Our forefathers came with their wives and their children, and their household stuff and their cattle, and most certainly caused as great a revolution in the farming of the country, which they conquered by the sword, as in its language and politics. Unfortunately, we do not know for certain what kind of ox they possessed in their native country, but the fact that the district between the Rhine and the Elbe is now famous for the large oxen, which are descended, according to Professor Nilsson, from the Urus, and are, therefore, cognate with those of Chillingham, coupled with the appearance of the latter animal in Britain about the time of the English conquest, renders it extremely probable that white cattle with red ears were imported into this country by its conquerors.

If this view be accepted we must show what breed of ox was possessed by the farmers during the Roman occupation, and fortunately the accumulation of bones left behind by the Roman provincials affords conclusive proof on the point.

The Romano-Celtic or Brit-Welsh Breed.

The remains of the smaller shorthorned ox, the deer-like *Bos longifrons* of Professor Owen, or the Celtic shorthorn, have been found, without exception, in every refuse-heap accumulated in Great Britain during the Roman age, that has been scientifically examined. So far as I know, it is the only breed which has left traces of its existence in

[1] Mallet, 'Northern Antiquities,' p. 291, 1770.

[2] 'The Anglo-Saxon Chronicle,' 'Monumenta Historica Britannica,' p. 298, A.D. 449. "From Anglia, which has *ever since* remained waste betwixt the Jutes and Saxons, came the men of East Anglia, Middle Anglia, Mercia, and all North-humbria." The MS. 'A,' from which this was taken, ends in A.D. 975.

Britain at that time ; and it presents, as might be expected, variations in size which would result from the herds being fed in different pastures and obtaining more or less food. Out of a large number of instances which have passed through my hands I will quote a few to illustrate, not merely the presence of the animal, but also the kind of food on which the Roman provincials lived in Britain.

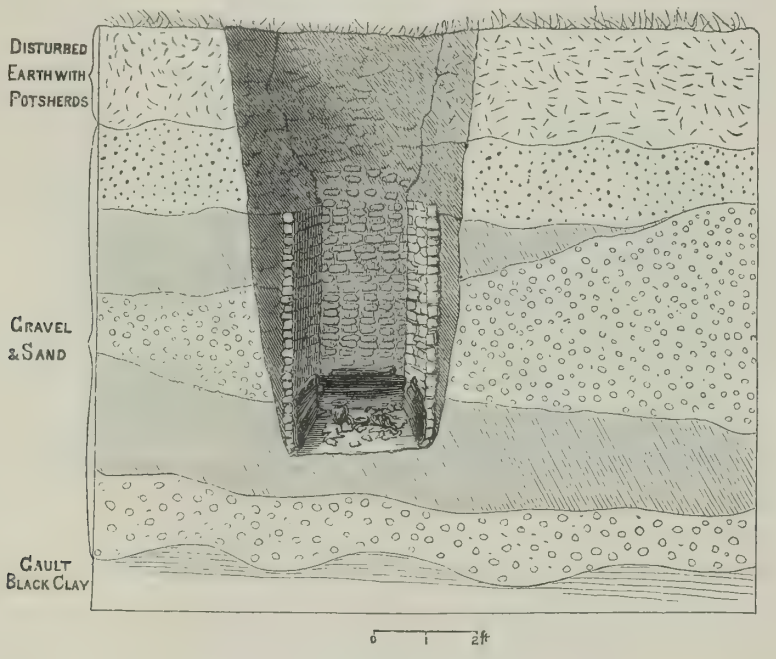
In 1864 I examined the remains in the magnificent collection of Mammalia at Taunton, found by the Rev. F. Warre in the hut-circles which exist within the massive fort of Worle Hill, near Weston-super-Mare,[1] that was occupied by a Roman garrison. They belonged to Celtic shorthorn, goat, horse, pig, badger, and stag, and from their fractured state clearly were the relics of the food in use at the time. They were associated with the following articles of metal—spears and arrow-heads, reaping hooks, and horse-trappings of iron, a ring, and some coins of bronze, the latter of Constans, Constantinus, and Crispus Valerianus. There were also red, green, and blue glass beads, the calcined head of a femur, and a liassic nodule perforated for suspension, a ring made of a segment of the shaft of the metatarsal of *Bos longifrons*, rude pottery, not turned in the lathe, lathe-turned and well-moulded Roman pottery, whetstones, flint-flakes, and one remarkable implement, pyramidal in form, with a flat base carefully chipped all round. This form was also found in the Celtic village of Stanlake by Mr. Stone, and by the Rev. H. H. Winwood in the excavations in ancient Roman Bath (Aquæ Solis). From the latter place the remains forwarded to me belong to the roe and red deer, horse, Celtic shorthorn, goat, and pig.

A collection of Roman remains, made by Mr. Thomas Honeywood, of Horsham, from a Roman villa on the South Downs, contained the following species—red and roe deer, wolf, fox, pig, Celtic shorthorn, and horse, shells of cockle, limpet, and periwinkle. The villa itself had undoubtedly been destroyed by fire, for a quantity of molten lead, derived probably from the roof, had fallen on a heap of corn, and still contains, within its mass, the carbonized grains. The same group of animals is represented also in the refuse heaps around and in the old Roman cities of Londinium (London) and Camulodunum (Colchester), as well as in the castrum of Othona or Itanceaster at the mouth of the Blackwater.

In the Maidstone Museum there is a collection made from a swallow-hole near Allington Church, consisting of remains of dog, wild boar (the turf hog?), sheep or goat, red and roe deer, along with shells of whelks, oysters, and periwinkles, Samian ware, fine black ware turned in a lathe, and Roman tiles. In all these cases it is worthy of note that the remains of the Celtic shorthorn are far more numerous than those of the red or roe deer. There is, moreover, reason to believe, from the fractured condition of the remains of horse, badger, and bear, that those animals also formed part of the people's food. The remains of the dog and of the wolf, on the other hand, are for the most part perfect, and without traces of fracture or of marks of the saw.

I have also met with traces of the dog, horse, and Celtic shorthorn inside oaken

chests at Hardham, near Pulborough, in Sussex, which contained interments of the age of the Roman occupation. From a coin of Hadrian (A.D. 172) found in one of them it is very probable that they belong to the end of the second century, or



Tomb in the Railway Cutting at Hardham.

between that date and the English conquest of the district. Inside each chest the ashes of the dead were buried in a vase, and around it lay bones of the animals which had either been eaten by the survivors, or placed for the use of the dead, along with various articles.

Chest inside Tomb with Articles *in sitû*.

In one case there was a pair of unworn sandals, and in a second a funnel for pouring liquids into bottles; and in all there were vases of different kinds. The cinerary urn rested either on a platform of broken flints or on a Roman tile. From one of the interments I obtained two flint-flakes, which, probably, had been deposited from some superstitious motive.

From these and many other instances it is clear that the Celtic shorthorn abounded in Great Britain during the Roman occupation, to the exclusion of the larger breed descended from the *Urus*, while the latter breed had increased to such a degree between the Roman occupation and the tenth or eleventh century that it was recognised by the Welsh themselves as being worth one third more than the small breed which their forefathers had possessed prior to the English invasion. That they were introduced by the English seems to be the only explanation of all the facts of the case, and this view derives additional weight from the opinion of the eminent historian, Mr. Freeman.[1] The English invader, he tells us, destroyed, as far as he could, everything that was Celtic and Roman. In the burnt Roman villas and the ruined Roman cities, and in the aversion which the invaders, of eastern Britain, showed to occupying the sites of Roman towns, and which is manifested by the position of their villages, we can recognise the antagonism of the two races, as well as in the destruction of the Roman tongue and the laws and Christianity. It is therefore, on the whole, almost certain that, the Celtic shorthorn was swept away along with the Celts, from all the parts of Britain conquered by the English, or so crossed and altered by the infusion of new blood, that at the present day the type is only to be found in the small dark cattle of Wales and Scotland, or exactly those parts whither their ancient masters fled for refuge. But, whether this be accepted or not, as the evidence stands at present the larger breeds of cattle began to appear in Britain about the same time as the English people, and the Celtic shorthorn began to disappear. The larger breeds must have been

[1] 'History of Norman Conquest,' vol. i, chapter 1.

imported from the Continent, and since the English people, as distinguished from the British, in common with their Scandinavian kinsmen, were herdsmen, and lived, moreover, in the country between the mouths of the Rhine and Elbe, now famous for its breeds of large cattle, it is impossible to shut our eyes to the full weight of the argument. The cattle of Schleswig at the present day are larger than the Chillingham ox, the living representative of the old breed, comparatively unaltered, but that is probably due to the care taken in breeding and to the superior richness of the pastures.[1]

These two breeds, therefore, are of interest, not merely from the biological point of view, but because they throw light on an obscure part of our history. Their present distribution in Britain should correspond with that of the Celtic and Teutonic populations. The highlands of Wales and Scotland, and till lately of Cornwall, have afforded a resting place for the Celtic shorthorn and its Celtic masters, while the larger herds of the Urus types have penetrated wherever the Teutonic invader has set his foot.

The view taken by Prof. Owen, that the larger breeds were introduced by the Roman coloni, and that the smaller shorthorn, along with its Celtic possessors, was then driven from the British lowlands, is negatived by the fact that no such larger oxen have been met with in any Roman accumulation in Great Britain, and that the Celtic shorthorn was, as we have seen, the food of the Roman provincials in the lowlands.

Romano-Celtic or Brit-Welsh Caves.

The same group of animals which occur in the refuse-heaps around Roman habitations is found also associated with traces of Roman civilisation in caves which have afforded shelter to man and the wild animals from the earliest times. The Victoria Cave, near Settle, in Yorkshire, explored by the Settle Cave Exploration Committee, has afforded the same animals, associated with fragments of pottery,

[1] See 'Brit. Foss. Mammals,' p. 500, and Royal Institution Lecture, 2nd May, 1856. "The small ox (*Bos longifrons*) is that which the aboriginal natives of Britain would be most likely to succeed in taming. They possessed domestic cattle (*pecora*) when Cæsar invaded Britain. The cattle of the mountain fortresses to which the Celtic population retreated before the Romans, viz. the Welsh 'runt' and Highland 'kyloe,' most resemble in size and cranial characters the Pleistocene *Bos longifrons*. Prof. Owen therefore regards the *Bos longifrons*, and not the gigantic *Bos primigenius*, as the source of part of our domestic cattle."

The view that the Celtic herdsmen retreated to Wales before the Roman legions is based on the historical error of supposing that the Romans came into Britain as the destroyers and the uprooters of the Celtic civilisation, instead of being rulers and organisers in the same way as Englishmen in India. The Celtic population did not fall back on the highlands of Wales and Scotland, but submitted to the Roman yoke, and Wales was as completely a portion of the Colonia as Essex or Kent. The idea also that the "aboriginal natives" of Britain tamed the *Bos longifrons*, or that the animal is of Pleistocene age, is unsupported by any proof. See 'Quart. Geol. Journ.,' 1867; "Brit. Foss. Oxen," part 2.

Samian ware, and Roman coins. Others, also, in Yorkshire, Cumberland, and Derbyshire, were occupied by the Brit-Welsh in the fifth or sixth centuries, and are fully described in the third chapter of my work on 'Cave Hunting.' That of Longberry Bank, near Penally, in Pembrokeshire, explored by the Rev. H. H. Winwood, F.G.S., contained the remains of Celtic shorthorn, sheep or goat, badger, dog or wolf, oyster shells, limpets, mussels, flint-flakes, a human vertebra, premolar, and metacarpal, along with fragments of red fine-grained pottery turned in the lathe, of a kind that is generally found in the refuse-heaps of Roman cities and villas.

Romano-Celtic or Brit-Welsh Food.

The list of the animals associated with Roman remains in Great Britain, proves that the principal supply of meat was obtained from flocks and herds rather than from the chase. In nearly every refuse-heap which I have examined there are the broken bones of the horse; and from their varying ages it may be inferred that they were kept for food, as well as for riding and driving. The bones of colts are rare, but so also are those of the old and worn-out horses; and they present an appearance very different from that which is offered by accumulations of horses' bones in the neighbourhood of kennels, as, for instance, that at Oulton, in Cheshire, the seat of Sir Philip Egerton. It is a remarkable fact that none of the horses of that time which have passed through my hands present any trace of the diseases of the bones of the extremities which are the result of the hardness of our modern roads. It would, indeed, almost seem that roadsters were then very uncommon, and that the horses were used principally for riding over the soft grass lands. But, however this may be, horseflesh was a more frequent dish in Roman Britain than venison. Horses were used for food in Britain as late as the year A. D. 787, if there be any truth in the charge made against the English in the Council of Chelsea, "Equos etiam plerique in vobis comedunt, quod nullus Christanorum in Orientalibus facit."[1] In Norway, Hacon, foster-son of Æthelstan, was compelled to eat horseflesh in honour of Odin in 956; and the bloody battle of Stikklestadt, in 1030, in which Olaf, the Saint, met his death, was fought on account of the cruelties which he practised on the eaters of horseflesh.[2]

Pork was almost as commonly used by the Brit-Welsh as the flesh of the sheep and goat, and the swine belonged principally to small domestic breeds, in which there was a large infusion of the blood of the *Sus Indica*, or the turf-hog. The dog was not eaten, for invariably the long bones are unbroken and untouched by the saw, while the Celtic shorthorn supplied the greater portion of the food.

[1] 'Concilia,' vol. vi, p. 1872.

[2] Laing's 'Sea Kings of Norway,' p. 316.

Principal Animals in Britain at beginning of Historic Period.

The following table will give an idea of the principal domestic and wild Mammalia in Britain during the time of the Roman occupation.

ROMANO-CELTIC OR BRIT-WELSH REFUSE-HEAPS.

	Hut-circles, Worle Hill.	Bath.	Villa near Horsham.	Allington Church, Maidstone.	London Wall.	Colchester.	Villa, Holyshute, Honiton.	The Victoria Cave.
Canis familiaris...Dog	...	...	...	×	×	×	×	×
Bos longifrons ...Celtic Shorthorn	×	×	×	×	×	×	×	×
Ovis aries .....Sheep	...	...	...	?	×	×	?	
Capra hircus .....Goat	×	×	...	×	×	×	?	×
Equus caballus ...Horse	×	×	×	...	×	×	×	×
Sus scrofa .....Hog	×	×	×	...	×	×	×	×
Canis lupus .....Wolf	...	...	×					
Ursus arctos .....Bear	...	...	...	...	...	×		...
Meles taxus .....Badger	×							
Cervus elaphus ...Stag	×	×	×	×	×	×	...	×
— *capreolus*, Roe	...	×	...	×	×	...	×	
— *dama* .....Fallow-deer	...	...	...	...	×			
Sus scrofa .....Wild Boar	...	...	...	×		...	...	...

Physiography.

The changes wrought in the physical geography of Great Britain during the historic time have consisted, in the main, of the cutting down of forests, and the drainage of morasses, and the reclamation of land from the sea by the hand of man, and these again have reacted on the rainfall. There are, however, other changes, which have been brought about by natural causes. The sediment, washed by the rain from the higher grounds, has accumulated in the mouths of the rivers, forming fertile plains at the expense of the sea. The ancient harbour, for instance, of Pevensey, the Roman Anderida, where the Roman galleys anchored, is now a meadow, and the massive Roman fort which commanded it is now shut off from the sea by green fields. Thanet, also, which was the first foothold of our ancestors in this island, and which at the time of their landing was separated from Kent by a broad channel, is now connected with it by a fertile stretch of alluvium. Many instances of this sort might be added.

[1] The remains from London Wall I identified in the collection of Gen. Lane Fox and the late Mr. Wickham Flower, those from Colchester in that of Dr. Bree, those of Holyshute were sent me by the discoverer, Mr. Swann.

But while the land has been encroaching on the sea in some places, the incessant action of the waves has been wearing away the land in others. Many ancient camps which were occupied by the Romans, on exposed portions of the sea-coast, have been partially destroyed, as, for instance, at Newhaven, and the long, low-lying tract of land which extends past Bognor and Selsea, in the direction of Portsmouth, is being swept away at the rate, at the very least, of one foot per annum along the whole coast-line.[1] There seems to have been no change of level since the historical period in the south part of Britain. The Roman road, discovered by Mr. Oliver, passing from Middlezoy, in Somersetshire, to the Polden Hills, was made after the morass, which it crosses, had assumed its present relation to the sea-level. The submerged forest which now excites the wonder of the Welsh peasants, and which probably was the sole foundation of the story of the lost lands of Wales, was noticed at its present level by Giraldus Cambrensis when he was gathering recruits for the first crusade.[2]

In Scotland Prof. Geikie has argued that the land has been elevated to a height of about twenty-five feet above the present level of the sea since the wall of Antoninus was built to keep out the Pictish and Scotish marauders. The wall runs from Carriden, on the Firth of Forth, to Chapel Hill, on the Firth of Clyde, leaving unprotected a space at either end, between its termination and the present sea-level, which would be defended by the sea were the land depressed to the extent of about twenty-five feet. Prof. Geikie therefore infers that it was so defended at either end at the time when it was planned by the Roman engineers. He also cites in favour of this view the raised mud-banks and ancient harbours, such as the carse of Stirling and the old Roman harbour of Cramond,[3] which are now above the mean sea-level. The recent discoveries, however, of a Roman road running across the carse of Stirling, defended by a fort, and of a tablet *in sitú* bearing an inscription commemorating the completion of part of the wall at Bowness, Linlithgowshire, at a height of nineteen feet above the sea, negatives the conclusion, as Sir Charles Lyell points out in the 4th edit. of the 'Antiquity of Man,' p. 56.

The presence of the reindeer in Scotland as late as the middle of the twelfth century implies that between that time and the present the climate has become warmer.

[1] This estimate is rather under than over the truth. When the writer was surveying this district in 1865 the land was being torn away by the current passing out of Pagham Harbour at an alarming rate, and the section offered by the low cliff varied every day. Probably before the end of the present century the fine old church at Pagham will share the fate of the old church at Selsea.

[2] 'Itinerarium Cambriæ,' book 1.

[3] 'Edinburgh New Phil. Journ., July, 1861.

The Wild Animals of Ireland.

The Mammalia now living[1] in Ireland are, with a few exceptions, identical with those of Great Britain. The common hare is replaced by a variety of the *Lepus variabilis*, or the Alpine species, found in Britain only in the highlands of Scotland. The stag, which was formerly abundant, still lingers in the wildest portions of Connaught, and lived near Killarney and in Tipperary in the year 1840. The precise date of the introduction of the fallowdeer, and of the roe, cannot be ascertained, but they certainly were introduced after the reign of Henry II, since the acute observer Girald Barry expressly states that they were not found in the country in his time. They were most probably brought over by some of the English lords, who were in the habit, in the beginning of the twelfth century, of keeping animals for pleasure and sport.[2] Girald Barry[3] also notices the absence of the beaver, and distinguishes between the wild boar and the forest-hog, and notes the extreme ugliness of the former animal.

The existence in Ireland of two distinct wild strains, which most probably may be referred to the wild boar and the turf-hog, of Prof. Rütimeyer, is confirmed by the mention of the "wild hog" and the "wild boar" among the animals paid for a ransom, in a manuscript preserved in Trinity College, Dublin.[4] The wild boar, according to Dr. Scouler, was plentiful as late as the seventeenth century, while the memory of the bear is preserved only in a tradition which may be of no historical value. St. Donatus, the Bishop of Fesole (died in 840), writes that in that happy isle "Ursorum rabies nulla est ibi!"

The wolf lived in Ireland late into the Historic period, and its ravages have caused its existence to be placed on record after the English conquest. Dr. Scouler, who has collected nearly all the notices on the point ('Journ. Geol. Soc. Dub.,' vol. i, p. 225), writes:

"Great numbers of wolves formerly existed in Ireland, and they maintained their ground in this country for a longer period than many other parts of the empire. Campion, whose 'History of Ireland' was published in 1570, informs us that wolves were objects of the chase. 'They (the Irish) are not, he says, without wolves, or greyhounds to hunt them, bigger of bone and limme than a colt.' A century later they appear to have been

[1] The authorities for the Irish Mammalia used in this paragraph are—Thompson, 'Nat. Hist. Ireland,' vol. iv, 1836; Scouler, 'Journ. Geol. Soc. Dublin,' vol. i, p. 225; Ball, 'Trans. R. I. Acad.,' 10th December, 1849; Wilde, 'Proceed. R. I. Acad.,' vol. iv, p. 416, and vol. vii, p. 193; Giraldus Cambrensis, 'Topographia Hiberniæ.'

[2] Alexander Neckam, 'De Naturis Rerum,' edit. by T. Wright, Esq., 8vo., 1863; Rolls' Publication.

[3] 'Topographia Hiberniæ.' The roebuck is mentioned in a poem preserved in Trinity College, Dublin, and ascribed to the ninth century, but the evidence as to its date is not satisfactory. See Sir W. Wilde, 'Proceed. Royal Irish Acad.,' vol. vii, p. 193.

[4] 'Proceed. Royal Irish Acad.,' vol. vii, p. 193.

equally abundant, for we find by the Journals of the House of Commons that in 1662 Sir John Ponsonby reported from the Committee of Grievances that a bill should be brought in to encourage the killing of wolves and foxes. Effective measures for this purpose appear to have been taken, and the wolf was at last extirpated about the year 1710. Dr. Smith, in his 'History of Kerry,' when speaking of certain ancient enclosures, observes that many of them were made to secure cattle from wolves, which animals were "not finally extirpated till the year 1710, as I find by presentments for raising money for destroying them in some old grand-jury books."

According to Mr. Thompson[1] three wolf-hills in Ireland claim their names from the killing of the last wolf, "one in the south, another near Glenairn, and the third three miles from Belfast."

The mischief done by these destructive creatures may be estimated by the various orders relating to them, which have been extracted from the Council Books preserved in Dublin by Mr. Hardiman.[2]

In 1652 the export of "wolfe dogges" was declared to be illegal by Cromwell's Government, "because the wolves doe much increase and destroy many cattle." In the following year also in the preamble of a Declaration touching the Tone it is stated that "many times poore children, who lost their parents or deserted by them, are found exposed to, some of them fed upon by, ravening wolves, and other beasts and birds of prey." This increase of the wolves is directly traceable to the devastated condition of Ireland after the rebellion had been ruthlessly stamped out by Cromwell. In the same year there is a third declaration ordering the destruction of wolves, to which their final extirpation in 1710 may be directly assigned. "And it is further ordered that all such person or persons who shall take, kill, or destroy any wolfes, and shall bring forth the head of the woulfe before the said Commanders of the Revenue, shall receive the sums following, viz. for every bitch wolfe, six pounds; for every dogg wolfe, five pounds; for every cubb which preyeth for himself, forty shillings; for every suckling cubb, ten shillings: and no woolfe after the last of September until the 10th of January be accounted a young woolfe, and the Commissioners of the Revenue shall cause the same to be equallie assessed within their precincts."

The date of the disappearance of the wolf from England, Scotland, and Ireland affords a clue to the physical condition of those countries at the time. The hunter had destroyed the only formidable carnivores to the shepherd and husbandmen in England before the close of the fourteenth century, in Scotland in 1686, and in Ireland in 1710, and the two survivors—the bear and wolf—of the band of larger heads of prey that dwelt here in the Pleistocene, Prehistoric, and Historic ages finally passed away from Great Britain and Ireland along with the forests and the morasses, in which they found shelter and food.

[1] 'Nat. Hist. of Ireland,' vol. iv, p. 34.

[2] 'A Chorographical Description of West Connaught,' by Roderic O'Flaherty; edit. James Hardiman, Dublin: Note D, p. 180.

[3] 'Arctic Zoology,' 4to, introd., p. iv.

Domestic Animals of Ireland.

The domestic animals of Ireland during the Historic period were the same as those of Great Britain. The small, deer-like oxen, which, according to Youatt, inhabited the mountains of Waterford, and were considered by him to be akin to the cattle of the Scotch highlands, may be referred to the small, shorthorned variety, *Bos longifrons*. The larger breeds are descended from the Urus, and the white cow, which has left its mark in the names of places, and is mentioned in old Irish records, shows that a breed akin to that of Chillingham was known in Ireland in early days.[1]

Fiach Finfoladh (finn = white, olaidh = cow) derived his name, according to the author of 'Cambrensis Eversus,' because in his reign white cows were known in Ireland, —*Hiberniæ boves eo regnante insigniebantur*.[2]

The date of their introduction is uncertain. Dun cows were known in Donegal before the year 1342, which is the latest date that can be assigned to the book which is called after their name.

The sheep, both horned and hornless, and the goat, and the large gaunt descendant of the wild boar, were domestic animals in the country as well as the horse. The domestic cat probably found its way into Ireland after its introduction into England, about the time of the first Crusades; the two cats mentioned in a MS. in Trinity College Library, and supposed to belong to the ninth century, most probably referring to the wild species.

[1] 'The Origin and History of Irish Names of Places,' by J. W. Joyce, Dublin; McGlashan and Gill, Upper Sackville Street, 1869; part 2, chap. iv, p. 156.

There is a small lake in the island of Inishbofin, off the coast of Connemara, in which there lives an enchanted white cow, or *bo finn*, which appears above the waters at certain times; hence the lake is called *Loch-bo-finne*, the lake of the white cow, and it has given name to the island. Bede calls the island Inis-bo-finde, and interprets it "the island of the white cow" (insula vaccæ albæ).

There is another Inishbofin in Lough Ree on the Shannon, which in Colgan's 'Life of St. Aidus' is similarly translated, and another off the coast of Donegal, south of Tory Island. We find also Loughbofin (the white cow's lake) and Loughboderg (of the red cow) on the Shannon. Corrabofin near Balligbay, in Monoghan (properly Carrowbofin, the quarter land of the white cow); Gortboffinna (gort, a field), near Mallow, in Cork; Drombofinny (drom, a ridge) in the Parish of Desertserges in the same county; Lisboduff (the fort of the *black* cow), in Cavan, and many others. It is very probable that these names are also connected with legends.

[2] The impossible date of A.D. 39 to 56 is assigned to this king. 'Cambrensis Eversus,' vol. iii, chap. viii, p. 461, Celtic Society, 1851.

The Principal Historic Mammalia of Great Britain and Ireland.

The following table represents the principal species which have inhabited Great Britain and Ireland in the Historic period.

		Mammals living during Roman occupation.	Mammals living at the time of the Norman Conquest.	Mammals living at the time of William and Mary.	Ireland.
Erinaceus Europæus, L.	Hedgehog	×	×	×	×
Talpa Europæa, L.	Mole	×	×	×	...
Ursus arctos, L.	Brown Bear	×	...	...	?
Meles Taxus, Schreb.	Badger	×	×	×	×
Martes foina, C.	Common Marten	×	×	×	×
Mustela erminea, L.	Stoat	×	×	×	×
— *putorius*, L.	Polecat	×	×	×	×
— *martes*, L.	Marten	×	×	×	×
— *vulgaris*, Briss.	Weasel	×	×	×	×
Lutra vulgaris, Erxl.	Otter	×	×	×	×
Canis vulpes, L.	Fox	×	×	×	×
— *lupus*, L.	Wolf	×	×	×	×
— *familiaris*, L.	Dog	×	×	×	×
Felis catus, L.	Wild Cat	×	×	×	×
— *domesticus*, Schreb.,	Domestic Cat	?	... ?	×	×
Cervus tarandus, L.	Reindeer	×	×	...	...
— *capreolus*, L.	Roe	×	×	×	...
— *elaphus*, L.	Stag	×	×	×	×
— *dama*, L.	Fallowdeer	×	×	×	...
Urus domesticus	Large Ox	...	×	×	×
Bos longifrons, Ow.	Celtic Shorthorn	×	×	×	×
Capra hircus, Gm.	Goat	×	×	×	×
Ovis aries, L.	Sheep	×	×	×	×
Sus scrofa, L.	Wild Boar	×	×	...	×
— *palustris*, Rüt.	Turf Hog	×	×	×	×
Equus caballus, L.	Horse	×	×	×	×
Lepus cuniculus, L.	Rabbit	×	×	×	×
— *variabilis*, Pall.	Alpine Hare	×	×	×	×
— *timidus*, L.	Common Hare	×	×	×	...
Arvicola pratensis, Bell	Bank Vole	×	×	×	...
— *agrestis*, Flem.	Field Vole	×	×	×	×
— *amphibius*, Dsmr.,	Water Vole	×	×	×	×
Sciurus vulgaris, L.	Squirrel	×	×	×	×
Mus musculus, L.	Common Mouse	×	×	×	...
— *minutus*, Pall.	Harvest Mouse	×	×	×	...
— *sylvaticus*, L.	Long-tailed Field Mouse	×	×	×	×
— *rattus*, L.	Black Rat	×	×	×	×
— *decumanus*, Pall.	Common Rat	×	×	×	×
Castor fiber, L.	Beaver	×	×	...	...

[1] Sir W. Wilde ('Proceed. Royal Irish Acad.') and Mr. Thompson ('Nat. Hist. Ireland,' vol. vi) are the principal authorities for the Irish Mammalia.

The absence of the beaver and the dormouse from Ireland must be due to the existence of some barrier to their westward migration from the adjacent mainland, and the fact that the Alpine hare is indigenous, while the common hare is absent, implies that, so far as relates to the former animal, the barrier did not exist. The bearing of this on the ancient geography of Britain and Ireland will be examined in the chapter which relates to the Prehistoric age.

Conclusion.

In this short sketch of the principal Mammalia of Great Britain and Ireland the most important facts to be noted are the that reindeer lingered in Caithness to the middle of the twelfth century, that the fallowdeer was introduced by the Romans in Britain, whence it found its way into Ireland, probably in the reign of Henry II. The larger breeds of cattle of the Urus type were imported into Britain, from their ancient homes, by the English, while the smaller dark animal, the *Bos longifrons*, which, as we shall see in the 4th Chapter, was the only domestic ox in Britain in the Prehistoric age, and as late in the Historic Period as the invasion of the English, retreated to the Highlands of Cornwall, Wales, and Scotland, along with the original Celtic and Gælic population. The larger oxen were probably brought into Ireland by the Scandinavians. The domestic cat was probably imported into Britain by the Romans, about the same time as the fallowdeer.

Neither the wild urus nor the bison have left any trace of their existence in the Historic Period, either in Britain or in Ireland.

CHAPTER III.

The Historic Mammalia of the Continent — The Wild Animals of Middle Europe—The Wild Animals of Northern Europe—The Wild Animals of Southern Europe—Italy, Greece, Turkey, and Southern Russia—The Domestic Animals on the Continent—Range of the Principal Wild European Mammalia—Climatal Change on the Continent—Conclusion.

Historic Mammalia of the Continent.

The Mammalia now living in Europe may be divided into three groups; the first consisting of those which inhabit the temperate regions of Central Europe, France, Germany, Belgium, Hungary, and Central Russia; of those which live in the district north of a line passing through the Baltic Sea; and, lastly, of those which live in the Iberian peninsula, Italy, and Greece, and of the district which stretches eastwards and southwards to the frontier of Asia.

The Wild Animals of Middle Europe.

When we compare the present wild Mammalia of Great Britain and Ireland with those now living in the temperate zone in the Continent we shall find that many of those which have been extinct in our country are still to be met with in the uncultivated districts. The beaver[1] still builds its dams in the Danube and the Rhine, and destroys the willow plantations of the Rhone, and is abundant only in the Dwina and the Petschora, and in the Caucasus. The wolf and the wild boar are still a terror to the herdsman and farmer in France, Germany, and Spain, as well as in Russia and Scandinavia; and the red deer affords an important supply of meat to the inhabitants in the forests of North Germany as well as in the wilds of Russia. According to a recent report[2] on the game

[1] The authorities for the following statements as to the range of the animals are Keyserling und Blasius, 'Die Wirbelthiere Europas;' Blasius, 'Saugethiere Deutschlands;' Bonaparti, 'Fauna Italica,' vol. i; Pallas, 'Zoographia;' Lord Clermont's 'Quadrupeds of Europe.'

[2] Report presented to Parliament 'On the Laws and Regulations relative to the Protection of Game,' 1871, part i, p. 6. In the year 1867 no less than 4288 head of deer were killed in the provinces of Prussia, and yielded 514,560 lbs. of meat.

laws in the wilds of Prussia it is now nearly as important as an article of food as in the middle ages in Britain. The common brown bear also is still to be found in the higher mountains of Central Europe, the Alps and the Pyrennees, and the Jura.

There are, however, as might be expected, many wild animals to be found in the temperate zone of the Continent which are unknown in Britain in the Historic Period, although, as we shall see in a later part of this work, some of them lived in our island before our history began. The lynx still seizes his prey in the forests of France, Germany, and Russia. The glutton (*Gulo borealis*), in the latter half of the eighteenth century, was to be found in Saxony and Brunswick,[1] although now the forests of Lithuania are the most southern points that it inhabits. The memorable passage in Cæsar's 'Commentaries' unfolds to us a group of animals which are now no longer found in the area in which they are described, or the Hercynian forest,[2] which extended from Aix-la-Chapelle to the north-east, and overshadowed North Germany. It afforded shelter to the elk, the great urus, and the reindeer, three animals which were then strange to the eyes of the Romans, and which, therefore, he picks out for description from those more commonly known. The first of these animals still inhabits the colder regions on the shores of the Baltic, in East Prussia, Lithuania, and Hungary. The urus lived in the forests of Aachen in the ninth century, and during the first crusades is incidentally mentioned as living also in Hungary. It became extinct about the fifteenth or sixteenth century. The reindeer is not known in Europe at the present time south of the Baltic, but in 1780 was, according to Pallas, living in the Urals and the Caucasus. As late as the ninth century the bison, or Wissent, or Aurochs, was hunted in the forests of France and Germany, and at the present time it lives on sufferance in Lithuania, preserved by a special edict of the Tzar.

The Alps and Pyrenees, and the high mountains of South Germany, afford shelter to the chamois and bouquetin, as well as to the marmot.

The fallow deer was probably introduced into France by the Romans from Africa or Spain, and thence it gradually found its way into Germany and Switzerland.[3]

The Mammalia of Northern Europe.

The common, or, as it is erroneously called, the Norway rat[4], is the only wild animal which has invaded Europe in the Historic Period. It was first observed in Europe in Southern Russia, according to Pallas, about the year 1727, and it is stated to have been

[1] The authorities for these statements will be given under the head of each species in the second Part of this Treatise.

[2] This was the opinion of the late M. Edouard Lartet, whom I consulted on the point.

[3] "Benedict. ad Mensas Ekkehardi, Monachi Sangallensis" (lines 117—136), 'Archæological Journal,' vol xxi.

[4] Bell, 'Brit. Quad.,' 315; Pallas, 'Glires,' p. 91; Pennant, 'Brit. Zool.,' i, p. 115; Clermont, op. cit., p. 97.

derived from the district of Astrachan. It arrived in France and Britain about three years afterwards, and has very nearly exterminated the indigenous species, the black rat (*Mus rattus*).

The wild and domestic animals of Switzerland in the eleventh century have been preserved, by a singular chance, in a grace written by Ekkehard the younger (A.D. 980—1036) for the use of the monks of St. Galle. Besides the bear, wild boar, chamois, bouquetin, marmot, roe, stag, and fallowdeer, all of which still live in Switzerland and the adjacent regions, the bison, urus, and the wild horse are mentioned, as well as the *Bos sylvanus*.[1] The last animal was most probably, like the *Taurus sylvestris*, which is mentioned in the life of St. Thomas, not a wild, but a domestic species, turned out to get its living in woodlands.

With these exceptions the Historic Mammalia of Middle Europe differ very little from those of Britain.

The northern regions present a fauna which differs from that at present inhabiting temperate Europe, in the presence of the reindeer, the lemming, the polar bear, the Arctic fox, as well as a peculiar lynx, *Felis borealis*, and the abundance of gluttons. We shall see in the course of this work how this northern group of animals crept southwards, until in the Pleistocene times it had full possession of Middle Europe.

Southern Europe.

The barren rock of Gibraltar affords a precarious existence to the only species of monkey found in Europe; and the neighbouring mainland of Spain is inhabited by the wild sheep.

The ape of Gibraltar, and the ferret[1] of Spain, have probably been introduced by man from the adjacent coast of Barbary.

The Iberian peninsula is stated by Varro to have possessed wild horses.[2] The fallow-deer still lives in the wilder regions. According to a report on the game-laws, presented to Parliament in the year 1871 in consequence of no well-enforced system for the preservation of game in the Iberian peninsula, there is a most alarming decrease in every species of game throughout the country. Pliny states that the rabbit is indigenous in Spain, and that it has spread over Europe from that centre; but this now is disproved, as Prof. Gervais writes, by the discovery of rabbits' bones in the prehistoric caves of France. The animal has also been found under the same condition in Belgium, by M. Dupont.

The Historic animals, wild in Italy, are essentially of the same species as those of

[1] Desmarest, 'Mammalogie,' sp. 273; Clermont, 'Quadrupeds and Reptiles of Europe,' p. 54.

[2] 'De Re Rustica,' 2, 1, 5.

Spain and Southern France, but there is no evidence of the presence of the urus or of the bison. The fallowdeer was introduced at a very early time, and became wild, if it were not, indeed, living in a wild state during the historic period. The latter opinion seems to me to be the most probable, since the animal is now wild in Spain and Sardinia. The highest and most inaccessible mountains also of Sardinia and Corsica are inhabited by the *Ovis musmon*. In the days of Varro[1] the wealthy Romans were in the habit of keeping in their parks animals in a semi-wild state, and he mentions the marmot, the alpine hare, and the rabbit, as being worth preserving, and he says that the preserves should be surrounded by a wall, so that neither wild cats nor wolves should be able to harry the game.

Greece, Turkey, and Southern Russia.

The fauna of Greece, Thrace, and Southern Scythia is far richer than that of Italy during the historic period. In the days of Herodotus the lion sought its prey in the mountains of Thrace, and before his time there is evidence, as Sir George Cornwall Lewis remarks, that it inhabited the Peloponnesus. In Aristotle's time the mountains and obscure region to the north of Greece and Macedonia supported both the urus and the bison. The former of these animals was apparently only known to the Greeks by the large horns and the hides, which they received in barter from the tribes who inhabited that district. The bison was, however, well known, and was even used as an illustration by the poet Sophocles in his famous chorus in 'Antigone:'—"By craft he (man) overreacheth the wild beast upon the mountain, and putteth to his yoke the long-maned steed, and the strength of the great bison."

As late as the days of Pausanias Peonian bulls were exhibited in the circus at Rome; and bisons are "mentioned by Dio as included in the great spectacle of Severus; and Martial even speaks of bisons being harnessed to Celtic cars on a similar occasion." These animals must either have been obtained from the forests of Thrace or from those of Gaul or Germany, since the means of transit to Rome from those points would be easier than any others.[2]

The bear and the wild boar have also left traces of their presence in the Peloponnese in the legends. The accomplished general, statesman, and writer, Xenophon,[3] in his treatise on hunting, mentions the lynx, panther, bear, and lion, as inhabiting Southern Thrace as well as a district in Asia Minor. And this isolated notice of the existence of the panther in Europe has been very generally considered to apply, not to Thrace, but to Asia Minor. It seems, however, to me to apply as well to the one as to the other, for although the

[1] 'De Re Rustica,' 3, 12.

[2] 'Notes and Queries,' Second Series, No. 9, p. 4.

[3] 'Treatise on Hunting,' cap. xxi, 1.

animal, like the lion, is no longer to be found in Europe, yet we have geological evidence that it spread over France, Germany, and Britain during the Pleistocene age. Moreover, it still lives in Asia Minor, from which the lion has now disappeared. The land fauna of Southern Europe and of Asia Minor is essentially the same, and at the present time, as in the days of Xenophon, the bear and the lynx, the wild boar and the red deer, are common to both regions.

There is every reason for the belief that when history began in Greece the greater part of the region to the north was overshadowed by forests, and that the wilds of Thrace extended, almost without a break of continuity, to join the Hercynian forest, the great stretches of woodlands in Rumelia, Bulgaria, Wallachia, and Hungary, the forests of the Hartz, and the Black Forest being now mere fragments, isolated by culture, of what was then one whole and connected wilderness.[1] The analogy of our own country, even as late as the time of James II, proves that this must have been the case. For if at that time, in so small and comparatively densely populated an island as Britain, only about one half of the area[2] was under cultivation, it is obvious that the cultivated land must then have borne an infinitely smaller proportion to the uncultivated on the Continent, where the population was small, and which was, according to Tacitus,[3] inhabited by wandering tribes, without possessing private property in land, and living partly by hunting and partly by their flocks and herds, and partly by a rude agriculture, and continually at war with each other. The knowledge which we may gather from the points where the civilisation of Greece and Rome touched the borders of this vast forest, and of the animals which lived in it, is therefore of great interest. The bison and the urus ranged throughout this vast area from North Germany as far south as the frontiers of Greece, while in the south the lion and the panther have had their memory preserved in the pages of Xenophon. It is, indeed, a point of considerable interest to note that, although the southern limit of the range of the lion in Thrace is defined with considerable accuracy by both Herodotus and Aristotle, its northern extent is not defined at all; it may have extended far over the Balkan range into the valley of the Danube within the historic period of Greece.

The Domestic Animals on the Continent.

The domestic animals in use throughout the Continent of Europe do not differ in the main from those which lived in Britain in the historic period. The cattle of Norway, France, Germany, Switzerland, Italy, and Spain belong to two distinct stocks, of which

[1] Tacitus, 'De Moribus Germanorum,' cap. 4, "Terra etsi aliquanto specie differt, in universum tamen aut silvis horrida aut paludibus fœda."

[2] See 'History of England,' by Lord Macaulay, vol. i, cap. 3.

[3] Tacitus, 'De Moribus Germanorum.'

the one is represented by the small short-horned *Bos longifrons* now living in Switzerland and Brittany, while to the latter, or to the urus type, all the larger breeds may be assigned. These two breeds were very widely known at the very beginning of history in the several countries. The horse also was universally known. The ass, on the other hand, which is of unknown antiquity in Asia, was used in Europe in the year 500 B.C., since, Herodotus mentions that some of Darius's cavalry were mounted on these animals when he invaded the valley of the Danube. It was probably well known to the Greeks from their intercourse with the Asiatics.[1] The Persians seem to have been in the habit of using them in their expeditions, since they are quoted also as beasts of draught in the army of Xerxes.[2]

The mule[3] also was used in Darius's expedition against the Scythians, and was imported into Rome before the days of Nero, since Pliny mentions the extravagance of Tophæa in having her mules' hoofs shod with gold.[4]

The buffalo[5] was introduced into Italy, according to Paulus Diaconus, in the year 596 A.D., to the intense astonishment of the Italian rustics. It is certainly that which is now preserved in the Roman Campana and the Pontine Marshes. The animal, according to Buffon,[6] was unknown in ancient Italy, and the present race is derived, according to him, from the Indian and African breed.

The domestic cat, as Sir G. C. Lewis and Prof. Rolleston, following the views of Dr. Lenz, have shown, was certainly introduced into Greece and Rome as early as the fourth century after Christ. To Prof. Rolleston we are indebted for an exhaustive analysis of the evidence as to its presence in Europe.

On looking into Ducange's 'Glossarium,' under the words "Catta" and "Cattinæ pelles," I find that Cæsarius, who was the physician brother of Gregory the theologian of Nazianzus, and who died A.D. 369, having been the friend of the second Constantine and Constantius, speaks of "ἐνδρυμους κάττας;" and I presume that the use of this expression shows with some degree of probability that tame cats were in use by this time in Constantinople. The date of Palladius is somewhat uncertain, though supposed, with a good deal of probability, to have been about the same as that of Cæsarius; but as his local habitation appears to have been Italy, his words[7] (lib. iv, cap. ix), "contra talpas prodest catos frequenter habere in mediis carduetis, mustellas habent plerique mansuetas," are of

[1] Herodotus, 4, 129.

[2] Id., 7, 56.

[3] Ἡμίονος, Herodotus, 4, 129.

[4] xxxiii, 11, 49.

[5] "Tunc primum caballi silvatici et bubali in Italiam delati Italiæ populis miracula fuerunt" (in 'Muratori Rerum Italicarum Scriptores,' vol. i, p. 457. Lib. iv, cap. xi, of Paulus Diaconus, "De gestis Langobardorum," vol. i, p. 457).

[6] Buffon, 'Quadr.,' t. v, p. 52; t. x, p. 67. See, also, Sir G. C. Lewis, 'Notes and Queries,' Second Series, vol. ix, pp. 4, 5.

[7] "De Re Rustica."

importance. They show that the two kinds of cat (*i.e.* cat and ferret) were both in use as domesticated animals, side by side, and at the same time in Italy, 900 years before the first of the Crusaders reached Constantinople, and in the days of Gratian and Theodosius, not those of Godfrey and Tancred. From the same authority, Ducange, I find that Evagrius (col. 436) many years later—indeed, almost a couple of centuries after the date ordinarily assigned to Palladius—still recognises αἴλουρος as the more correct denomination for *Felis domesticus*, saying, as though the word κάττα were a somewhat trivial and over-familiar designation, αἴλουρον ἣν κάτταν ἡ συνήθεια λέγει (lib. vi, 24).[1]

It is clear from this that the domestic cat was known in Rome and Constantinople in the middle of the fourth century A.D., and that the γαλῆ of Aristophanes and Aristotle, which eats snakes, eggs, and honey, and follows mice into their holes, is a ferret, and not the domestic cat. The latter animal, however, is represented in some of the Mosaics of Pompeii, and its remains have been discovered along with those of the other domestic animals, dogs and horses, destroyed by the showers of ashes which overwhelmed the city. It was, therefore, known in Southern Italy in the first century before Christ.

On the whole, it is surprising how little change has taken place in the domestic fauna of Europe. Among the oxen the types of *Bos longifrons* and urus have been clearly defined for an unknown length of time. The swine, since the beginning of the Historic Period, have varied principally in the direction of fatness, and the horse does not present any considerable difference. The dog, on the other hand, being the object of human caprice, has varied to such a degree that it is almost impossible to recognise the breeds of a hundred years ago in their lineal descendants. We must, therefore, seek for the origin of these animals in the period which precede history in the various countries of Europe, and we may infer, from the wideness of their distribution that they have been in Europe for a considerable time before history began.

Range of the principal European Wild Mammalia.

The following list of the principal European mammalia, showing their range in the various countries, is based on the works of Desmarest, Fischer, Blasius, Buonaparte, and Pallas, and the species which are now living in each country are distinguished from those which formerly lived in the same area during the historic period. Some animals, such as the cosmopolitan brown rat, and others, such as the smaller rodents and the bats, have been purposely omitted.

[1] Rolleston, 'Journ. Anat. and Phys.,' 1868, pp. 51, 52.

Table of the Principal European Wild Mammalia.

	Northern Europe.	France.		Germany.		Middle Russia.	Switzerland.		Iberian Peninsula and Gibraltar.	Italy, Sardinia, and Corsica.	Greece & Turkey.		South Russia.
		Alive.	Historic.	Alive.	Historic.		Alive.	Historic.			Now living.	Historic.	
Macacus inuus, L. ..... Barbary Ape	...	...	...	...	...	...	...	...	×	...	...	...	...
Myogale moschata, L. ..... Musk Shrew	...	...	...	...	...	...	...	...	...	...	...	...	×
— *Pyrenaica*, Geof. ... Pyrenees Shrew...	...	×	...	...	...	...	...	...	×	...	...	...	...
Erinaceus Europæus, L. ..... Hedgehog	×	×	...	×	...	×	×	...	×	×	×	...	×
Spermophilus citillus, L..... Pouched Marmot.	...	...	...	×	...	×	...	...	...	...	...	...	×
Arctomys marmotta, L..... Marmot	×	×	...	×	...	×	×	...	...	×	...	...	...
Lemmus Norvegicus ..... Norway Lemming	×	...	...	...	...	×	...	...	...	...	...	...	...
Castor fiber, L..... Beaver	×	×	...	×	...	×	...	×	...	...	...	...	×
Lagomys pusillus, Tal.	...	...	...	...	...	...	...	...	...	...	...	...	×
Lepus timidus, L..... Hare	×	×	×	×	×	×	×	×	×	×	×	×	×
— *variabilis*, Pall. ..... Alpine Hare	×	×	...	×	...	×	×	...	...	×	?	...	...
— *cuniculus*, L. ..... Rabbit	...	×	...	×	...	...	...	...	×	×	×	...	×
Hystrix cristata, L..... Porcupine	...	...	...	...	...	...	...	...	×	×	×	×	...
Felis leo, L. ..... Lion	...	...	...	...	...	...	...	...	...	...	...	×	...
— *lynx*, L. ..... Lynx	×	×	...	×	...	×	×	...	×	...	×	×	×
— *catus* ..... Wild Cat	×	×	...	×	...	×	×	...	×	×	×	...	×
— *pardina*, Oken..... Southern Lynx ...	...	...	...	...	...	...	...	...	×	...	×	...	...
— *borealis*, Thun..... Northern Lynx ...	×	...	...	...	...	...	...	...	...	...	...	...	...
— *pardus*, L. ..... Panther	...	...	...	...	...	...	...	...	...	...	...	×	...
Mustela martes, Briss..... Pine Marten	×	×	...	×	...	×	×	...	×	×	×	...	×
— *foina*, Briss. ..... Common Marten .	×	×	...	×	...	×	×	...	×	×	×	...	×
Fœtorius putorius, L. ..... Polecat	×	×	...	×	...	×	×	...	×	×	×	...	×
— *erminea*, L. ..... Stoat	×	×	...	×	...	×	×	...	×	×	×	...	...
— *furo*, L..... Ferret.....	...	...	...	...	...	...	...	...	×	...	...	...	...
— *lutreola*	×	...	...	...	...	...	...	...	...	...	...	...	...
— *Sarmaticus*, Pall.	...	...	...	×	...	×	...	...	...	...	...	...	×
— *Boccamila*, Cetti	...	...	...	...	...	...	...	...	...	×	...	...	...
— *vulgaris*, Briss..... Weasel	×	×	...	×	...	×	×	...	×	×	×	×	×
Lutra vulgaris, Erxl. ..... Otter	×	×	...	×	...	×	×	...	×	×	×	...	×
Meles taxus, Schreb. ..... Badger	×	×	...	×	...	×	×	...	×	×	×	...	×
Gulo borealis, Nilss..... Glutton	×	...	...	...	×	...	...	...	...	...	...	...	...
Ursus arctos, L. ..... Brown Bear	×	×	×	×	×	×	×	...	×	×	×	×	×
— *maritimus* ..... Polar Bear.....	×	...	...	...	...	...	...	...	...	...	...	...	...
Canis lupus, L..... Wolf	×	×	×	×	×	×	×	×	...	×	×	×	×
— *aureus*, L. ..... Jackal	...	...	...	...	...	...	...	...	...	...	×	...	×
— *corsac* ..... Corsac Fox.....	...	...	...	...	...	...	...	...	...	...	...	...	×
— *melanogaster*, Bonap. ... Black-bellied Fox	...	...	...	...	...	...	...	...	...	×	...	...	...
— *vulpes*, L..... Common Fox.....	×	×	...	×	×	×	×	...	×	×	×	...	×
— *lagopus*, L. ..... Arctic Fox	×	...	...	...	...	...	...	...	...	...	...	...	...
Equus caballus, L. ..... Horse.....	...	...	...	...	×	...	...	×	×	...	...	×	×
Cervus capreolus, L. ..... Roe	×	×	...	×	×	×	×	×	...	×	×	...	×
— *elaphus*, L..... Stag	×	×	×	×	×	×	×	×	×	×	×	...	×
— *dama*, L. ..... Fallow-deer	...	×	...	...	...	...	×	×	×	×	×	...	...
— *alces*, L..... Elk.....	×	...	...	×	×	×	...	...	...	...	...	...	×
— *tarandus*, L. ..... Reindeer	×	...	...	...	×	×	...	...	...	...	...	...	...
Bos urus, L. ..... Urus	...	...	×	...	×	...	...	×	...	...	...	×	...
— *bison* ..... Bison	...	...	×	...	×	×	...	×	...	...	...	...	×
Capella rupicapra, L. ..... Chamois.....	...	×	...	×	...	...	×	×	×	...	×	...	...
Capra Caucasica, Göld.....	...	...	...	...	...	...	...	...	...	...	...	...	×
— *ibex*, L. ..... Ibex	...	×	...	×	...	...	×	...	...	...	...	...	...
Antilope Saïga, Pal..... Saïga	...	...	...	...	...	×	...	...	...	...	×	...	×
Ovis musmon, Bou.	...	...	...	...	...	...	...	...	×	×	...	...	...
Sus scrofa ferus ..... Wild Boar	...	×	×	×	×	×	×	×	×	×	×	×	×

Climatal Change on the Continent.

The presence of the reindeer in the Hercynian forest in the days of Cæsar shows that the climate of North Germany was more severe than at the present time, just as the reindeer of Caithness tell the same story of the climate of Britain in the twelfth century. This conclusion is considerably strengthened by the fact, brought forward by Gibbon, that in the days of Tacitus the Germans were in the habit of crossing over the Rhine and the Danube[1] with their waggons on a solid bridge of ice to invade the Roman provinces. Such a severity of winter cold as is implied by this is at the present time exceptional. This climatal change can scarcely be considered as the result of the cutting down of forests or of the drainage of morasses: it is rather to be viewed as the last phase of a great secular change, which began far out of the reach of history, and affected the northern hemisphere before man had begun to make any impression on forest or morass. From the glacial period down to the present time the temperature of north-western Europe has gradually been rising.

Conclusion.

In this and the preceding chapters the historic mammalia of Europe have been briefly enumerated. As we pass backwards in time we see that the reindeer ranged further south than it does at the present time. We shall see that it ranged still further south in the prehistoric age, and ultimately in the Pleistocene, it reached the Alps and Pyrenees. It is surprising that the lion, the panther, and the urus, are the only three mammals which have been exterminated in Europe. The principal interest centres in the domestic animals. The fact that the urus breed was introduced into Britain by the English is most important for the student of history. The distribution of the fallow deer was due to the direct influence of the Roman power, while the northward distribution of the cat stands in direct relation to the intercourse which the people of France, Germany, and Britain had with the south and east of Europe.

[1] See 'Decline and Fall,' i, chapter ix.

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